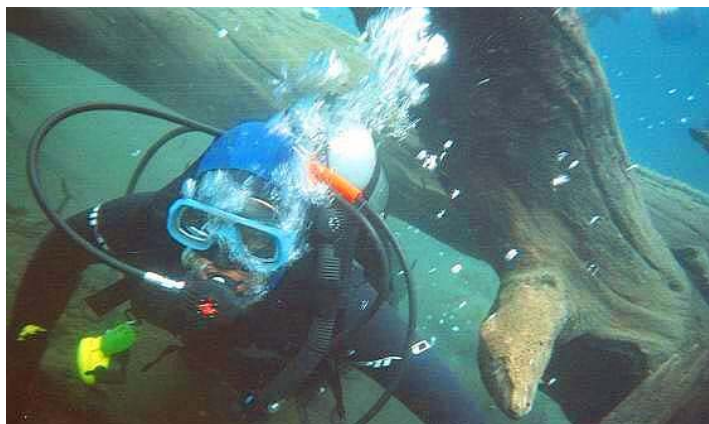


HIGH ADVENTURE RECREATIONAL ACTIVITY COMPARISON

An Interactive Qualifying Project Proposal
For the Washington, D.C. Project Site



High Adventure Recreational Activity Comparison

An Interactive Qualifying Project Report
For the Washington, D.C. Project Site

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1. Risk
2. Safety
3. Sports

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Abstract

The goal of this project was to compare possible risk factors associated with selected High Adventure Recreational Activities and create possible risk mitigation strategies from these comparisons. Our research involved gathering information on risk management, injury statistics, and participant behavior trends. The final result was recommendations to CPSC about potential risk mitigation strategies and possible improvements to their methods of collecting and analyzing nationwide injury data.

Executive Summary

The American population has enjoyed participating in high adventure recreational activities for many years. Their continued enjoyment comes from these activities providing them with healthy physical activity, the camaraderie of other participants, and the excitement of challenging one's self. The only disadvantage of this is that in order to reach a level of excitement there needs to be an amount of risk involved with the activity. This is in contrast to how people normally function in their day to day lives where they have an innate predisposition to avoid danger. This attitude changes when a person is in an altered environment, commonly seen in high adventure recreational activities. The potential risks in these activities, such as broken bones, concussions, or lacerations, are well known. People, who live sedentary lives, spending countless hours in front of the computer or television, put themselves in just as much jeopardy in the long term, increasing their chances of heart disease or diabetes. The common factor in both types of situations is the presence of risk. The issue facing society is how to best avoid, reduce, or mitigate the risk that is apparent in the presence of recreational activities without denigrating its quality by increasing costs or applying strict regulations.

The Consumer Product Safety Commission, or CPSC, is an independent, government regulatory agency created by the Congress. The CPSC is responsible for protecting the public from undue risk with consumer products. The CPSC's mission includes the research of HARAs to determine if the level of risk is acceptable. If the risk is unreasonable, the CPSC is obligated to inform the public of the hazards and take steps to mitigate the risk involved, ranging from creating voluntary manufacturer/importer standards to banning the product altogether.

The CPSC is currently investigating the issues of certain high adventure recreational activities because over the past few years they have noticed a dramatic increase in the number of participants as well as an increase in injuries and fatalities associated with these activities. This project team has investigated ATV riding, SCUBA diving, rock climbing, and skiing as activities that exhibit high injury rates. For example, from 2000 to 2005, estimates of ATV injuries increased from 92,200 to 136,700 and the estimated number of ATVs climbed from 4.2 to 7.6 million. The fastest growing group of participants in ATV riding is children under the age of 16. Children have accounted for more than 30% of injuries and more than 20% of the fatalities related to ATVs since 1997.

The CPSC has also shown interest in the behavioral issues associated with these HARAs. SCUBA diving may be perceived as a more dangerous sport due to its equipment requirements and aquatic nature, but thousands more people are injured in ATV incidents each year than in SCUBA diving. Reasons explaining this difference may include the amount of training required, the participant's and surrounding culture's mentality, and a participant's level of experience.

Our goal was to advise the CPSC about an effective mean to reduce the risk in an activity by comparing it to other activities then determining if risk mitigation strategies used in other activities could be applied to the selected activity. We were able to derive strategies for risk management associated with four high adventure recreational activities: All-Terrain Vehicle riding (ATVs); skiing; SCUBA diving, and rock climbing. This goal was accomplished in four stages. First, our team began by looking at the patterns and trends illustrated by the injury and fatality data associated with our chosen high adventure recreational activities. Second, our team researched what risk management strategies have been used, in each activity as well as other related activities. Third, interviews were conducted with representatives of various trade associations and user groups, including participants in HARAs. Lastly, our team synthesized the findings from the analysis of the injury data and risk management options and formulated recommendations for the CPSC.

The first resource that our team used was the electronic databases provided by the CPSC. These databases include the National Electronic Injury Surveillance System or NEISS, In-Depth Investigation or IDI, news clips, and hotline databases. These four databases gave a variety of information such as injury and fatality statistics, in-depth reports of the scenario surrounding an incident, and what consumer products were involved. These databases allowed our team to break down our activities by region, age, race, sex, severity of injury, location of injury, and many other factors that could have affected these incidents.

Our group conducted a number of interviews with participants, participant organizations, and risk theorists who are familiar with our chosen HARAs. The goal of these interviews was to develop an understanding of the risks involved with a specific activity, what is being done to mitigate these risks, what could be done, and an effective ways to market these mitigation and compliance strategies. This information was then compared to the NEISS and IDI database data to see if possible trends, which were shown in the database data, could be explained by behavioral aspects within the activity.

The end result, or goal of this project was to compare the four researched HARAs to each other. The comparison was made with the intention of finding factors that mitigated the risk in each of the four activities that could be applied to the other three. After reviewing the collected data, the first conclusion our team came to was that the data were insufficient to substantiate a direct comparison. The comparisons that could be made were less conclusive than first anticipated.

The CPSC databases, which were to provide the statistical backing of our research proved to be insufficient. The estimates that our team generated using the National Electronic Injury Surveillance System (NEISS) were not representative of the entire population because the sample used to generate the injury rate estimates was small. A slight change in the number of injuries reported could have a drastic impact on the resulting estimate. This issue was a factor for all of the activities, which made it difficult to draw conclusions concerning trends from one year to the next. This is because of the wide confidence intervals of the NEISS estimates. For example, a NEISS injury estimate may be increasing over the course of several years, but because the confidence intervals are so wide the actual number of injuries could be increasing, decreasing, or remaining constant. The In Depth Investigation Database (IDI) was expected to hold clues that could indicate the causes of injuries and fatalities. However the sample size of the IDI database was even smaller, and could not be used to draw conclusions with any amount of certainty. These problems could not be solved outside of CPSC either; because despite the lack of data within the CPSC, no other government agency or private organization has data comparable to that of the CPSC.

The recommendations that our group made can be divided into five categories; database improvements, additional data needed, training, safety improvements, and future projects. Database Improvements and Additional Data Needed sections detail what could be done to improve the statistical data used to judge trends in HARAs. Training and Safety Improvements cover actions that could be taken in the activities reduce the level risk associated with them. The last section, Future Projects, provides the CPSC with ideas for continued research into HARAs. Some of our more important recommendations are as follows.

- Improve the National Electronic Injury Surveillance System (NEISS) database.
 - Make additional categories that are activity-based and not completely product-based.
 - Divide injury categories into more specific classifications. For example dividing “other” in SCUBA into various injury types such as barotraumas, epicondylitis, and the bends to better define a problem with an activity.
 - Increase the sample size to develop a better and more representative estimate, while maintaining a stratified system.
 - Less than 2% of hospitals in the US are currently sampled.
 - These changes would be very complex and would take a great deal of work to accomplish, but would be very beneficial to the agency. Being able to search this already extensive database by activity would allow for comparisons between activities to be made quickly and easily.
- Create and mandate a certified training program for ATVs.
 - According to the data gathered in this investigation, it is our opinion that mandating training with the sale of any new ATV will help to reduce the number of injuries. When investigating SCUBA diving and rock climbing, it was shown that there were a relatively low number of injuries and a high number of participants that had taken a training course. Mandating training with the sale of a new ATV will ensure that all new participants and some of the current participants receive a basic training course from a certified instructor. This training should include: safe operation of an ATV (turning, types of terrain, etc.), use of safety gear, and handling of emergency situations. A certificate or card could be issued to identify participants who have taken the course. Keeping records of who has taken the course will also help the CPSC develop a better participation estimate for the activity. State agencies, such as the departments of motor vehicles or DMV, could store these records, giving the CPSC relatively easy access them. It would have to be investigated if DMVs could afford to provide this service due to budget and manpower limitations.
 - As specified in the existing voluntary standard, each participating ATV dealer should offer a free course with the purchase of a new ATV. Although these courses

are free of charge they are still not being attended. Mandating the training would make sure that everyone who purchases an ATV will receive proper training.

- Adopting a basic training curriculum into a voluntary standard, like SCUBA has done, may help ensure that the basic information is taught.
- Creating a certified ATV training program is very feasible. There are already various participant groups, such as the ATV Safety Institute, that have created safety courses that could be used as models.

The recommendations that were made could only be broad generalizations. The lack of sufficient data made it impossible for the creation of a concise and directed approach for reducing injuries or mitigating the risks related to these activities. This is not saying that our recommendations would not have an impact. It's that the process of comparing different HARAs to each other must first be improved before action can be taken that would probably create positive results.

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Glossary

AASI- American Association of Snowboard Instructors
AMA- American Medical Association
AMGA- American Mountain Guide Association
ASCA- American Safe Climbing Association
ASI- ATV Safety Institute
ASTM- American Society for Testing and Materials
ATV- All-Terrain Vehicle
ATVA- All-Terrain Vehicle Association
CPSC- Consumer Product Safety Commission
CV- Coefficient of Variance
DAN- Diver's Alert Network
EPA- Environmental Protection Agency
FAQ- Frequently Asked Questions
FVATVA- Fox Valley ATV Association
HARA- High Adventure Recreational Activity
HIPPA- Health Insurance Portability and Accountability Act
IDI- In-Depth Investigation
IFMGA- International Federation of Mountain Guides Association
ISO- International Organization for Standardization
LAC- Los Angeles Council
NWSCC- North West Ski Club Council
MEB- Middle Ear Barotrauma
MSCC- Medical Services Call Center
NAUI- National Association of Underwater Instructors
NEISS- National Electronic Injury Surveillance System
NHTSA- National Highway Traffic Safety Administration
NPR- Notice of Proposed Regulation
NSAA- National Ski Areas Association
NSGA- National Sporting Goods Association
NSP- National Ski Patrol
OCSSDI- Ohio Council of Skin and SCUBA Diving Inc.
PADI- Professional Association of Diving Instructors
PDE- Project Dive Exploration
PSHI- Potentially Serious Head Injuries
PSIA- Professional Ski Instructors of America
SCMA- Southern California Mountaineers Association
SCUBA- Self Contained Underwater Breathing Apparatus
UL- Underwriters Laboratories
USNRC- United States Nuclear Regulatory Commission
VASA- Vermont ATV Sports Association
WHO- World Health Organization

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1 Introduction

The American population has enjoyed participating in high adventure recreational activities for many years. Their continued enjoyment comes from these activities providing them with healthy physical activity, the camaraderie of other participants, and the excitement of challenging one's self. The only disadvantage to this is that in order to reach a level of excitement there needs to be an amount of risk involved with the activity. This is in contrast to how people normally function in their day to day lives where they have an innate predisposition to avoid danger. This attitude changes when a person is in an altered environment, commonly seen in high adventure recreational activities or HARAs. The potential risks in these activities, such as broken bones, concussions, or lacerations, are well known. People, who live sedentary lives, spending countless hours in front of the computer or television, put themselves in just as much jeopardy in the long term, increasing their chances of heart disease or diabetes (WHO, 2007). The common factor in both types of situations is the presence of risk. The issue facing society is how to best avoid, reduce, or mitigate the risk that is apparent in the presence of recreational activities without denigrating its quality by increasing costs or applying strict regulations.

The Consumer Product Safety Commission (CPSC) is an independent, government regulatory agency created by the Congress and is responsible for protecting the public from undue risk with consumer products. Among the consumer products under inspection is the equipment used in high adventure recreational activities (HARAs). Other non-governmental agencies such as the Specialty Vehicle Institute of America (SVIA) and the American National Standards Institute have created guidelines to protect the public against consumer products. The CPSC's mission entails the research of HARAs to determine if the level of risk is acceptable. If the risk is above a socially acceptable standard, the CPSC is obligated to inform the public of the hazards of the product and will take steps to mitigate the risk involved, ranging from creating voluntary manufacturer standards to banning the product altogether.

Each year millions of Americans participate in HARAs, ranging from a single weekend outing to a yearlong hobby. Of these millions a percentage of them will experience an accident that will result in injury. The cause of these accidents can be traced back to a number of factors

that can vary from incident to incident, but it is likely that patterns do exist. The goal of our research was to determine possible risk mitigation strategies for four HARAs: All Terrain Vehicle (ATV) riding, SCUBA diving, skiing, and rock climbing. After developing an estimate of the rates of injury and the factors leading to these injuries, they were categorized and analyzed for trends. The statistical data was supplemented with a behavioral analysis of the participants. Based on this combination of quantitative and qualitative data our recommendations to the CPSC were provided a substantive foundation.

The following paper can be divided into five sections; Literature Review, Methodology, Findings, Conclusions, and Recommendations. The Literature Review provides background information on each of the investigated activities, risk theory, and risk management. The Methodology section details the process used to gather the information needed for our research. The Findings section lists our research results and their analysis. The Conclusions section provides a summary of the end result of the project and details what comparisons were able to be made between the activities. Recommendations are the final section and are a list of what can be done to improve safety and how the CPSC staff analyzes HARAs.

2 Literature Review

Comparing high adventure recreational activities is much more complex than just looking at the number of injuries and deaths in a year. It first involves gathering information on the history of the HARAs. Each of the researched activities; ATV riding, skiing, SCUBA diving and rock climbing there is a section of the Literature Review providing a detailed description of it. The Literature Review begins with risk theory and risk management in order to provide a concept of what factors should be considered when analyzing each of the HARAs.

Risk is a highly subjective term and can be defined in multiple ways. Two contrasting views of how to define risk are those of renowned risk theorists, Christoph Hohenemser and Paul Slovic. Hohenemser defines risk as the probability of death (Hohenemser, 1985); whereas Slovic defines it as a quantitative measure of hazardous consequences expressed as conditional probabilities of experiencing harm (Hohenemser, 1985). Because of these multiple definitions, assigning priority to risk-related hazards can be difficult. Society generally views risk as traumatic events that are outside of their control. Thus there has been more government funding for homeland security rather than consumer safety, even though the likelihood of being hurt in a terrorist attack is less than that of being hurt by a consumer product.

The management of risk is a complex and constantly changing issue. It involves individual citizens and multiple layers of government. When the CPSC staff believes that a control over a risk must be established, it follows a process that can be broken down into discrete steps. First, a government agency gathers information on the product or activity that is causing the risk. Using this information, the agency makes an assessment and determines whether control measures should be initiated that prevent, reduce, redistribute, and/or mitigate the risk. The control measures could involve a mandate, encouragement of product or behavior modification through punishment or reward, or a public relations campaign about the risks involved and what could be done to prevent or reduce risk.

2.1 Risk Theory

Risk is a vague term that can be viewed on a micro and macro level. Theodore Glickmann argues that the way risk is defined “can affect the outcome of policy debates, the allocation of resources among safety measures, and the distribution of political power in society”

(Glickmann, 1990). Risk can be broken down into two factors, probability (the likeliness of an event) and severity (the magnitude of an event). The analyses of these terms explain why people take unnecessary risks.

Figure 1 represents stated probability, the actual chance of an event occurring, and subjective probability, a person’s belief of an event occurring, with respect to a standard slope of equal representation. If the probability of an event is low, a person should view the event as an unlikely occurrence; an event of high chance should be perceived as a likely event. The small area before the intersection of the standard slope indicates that people perceive the probability of a rare event higher than its actual occurrence. The area after the intersection of the standard slope indicates that people perceive the probability of a common event lower than its actual occurrence. A person who gambles is likely to believe his odds of a net gain are more likely than a net loss. In an opportunity for a 50% “double or nothing”, a person will either underestimate the chances of winning again and not take a chance or will underestimate the chances of losing and will attempt to double his or her winnings (Wickens, 1999).

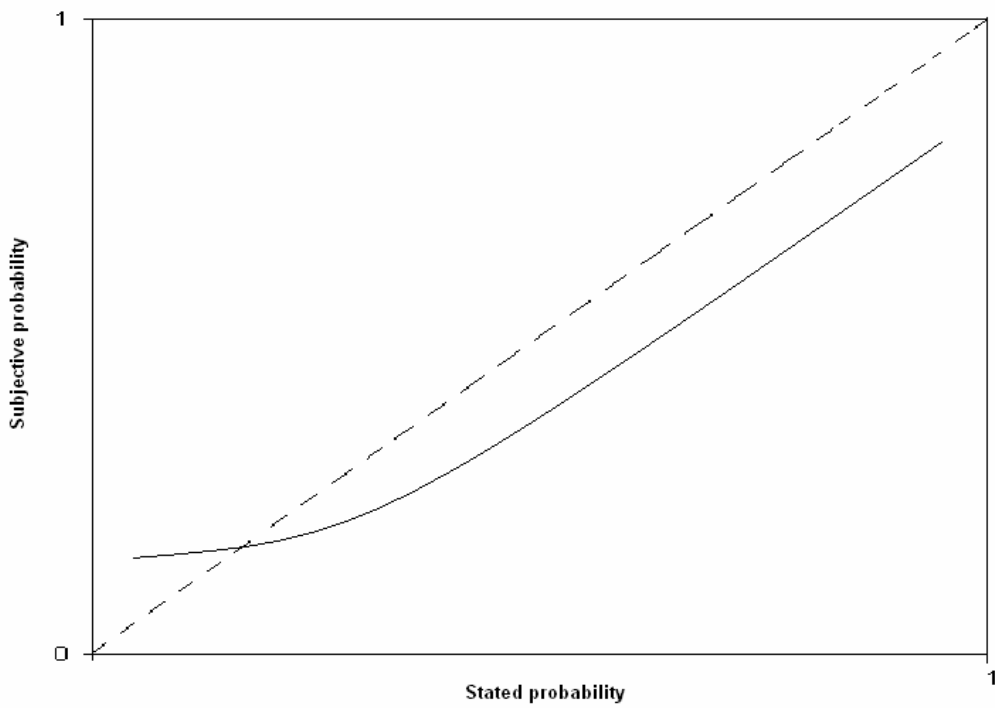


Figure 1: Variable Probability (Wickens, 1999)

Figure 2 represents a measurement of severity with respect to utility, the items being received, and value, the worthiness of those items to the person. Any immediate gain or loss is

considered to be judged higher than any additional gain or loss. For example, if a person repeatedly wins \$10 in several gambles, the value of the \$10 profit will drop after the person has won a significant amount of money. Meanwhile, repeatedly losing \$10 will have a higher value initially until losing \$10 after a significant loss of money. In a situation of initial gain or loss in overall utility, a person is more likely to reject the opportunity due to the loss of value being greater than the gain of value (Wickens, 1999).

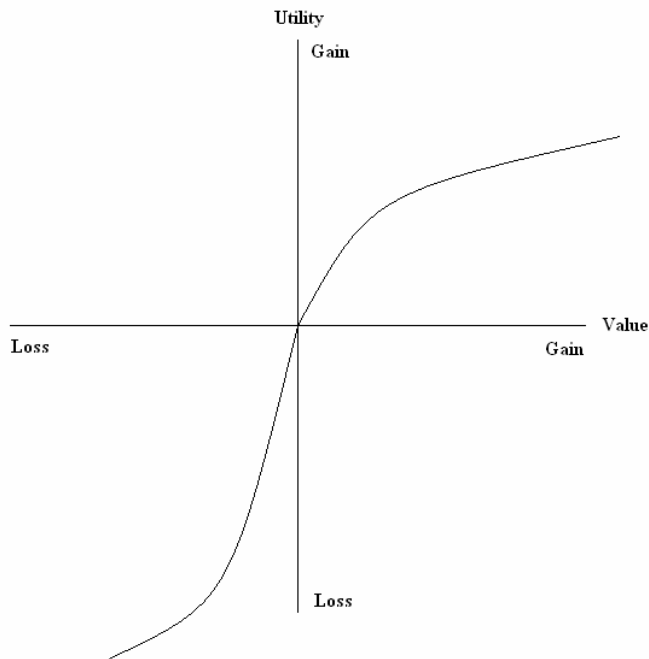


Figure 2: Variable Severity

(Wickens, 1999)

While many daily activities always carry a certain amount of risk, some activities are given more attention than others. Comparing the number of people injured or killed in different scenarios is a false comparison; a substantial number of people injured yearly does not equate to a high rate or high chance of injury. In 2006, there were an estimated 1.7 million injuries and 40,000 fatalities caused by automobiles (Insurance Information Institute, 2007). Auto injuries take place about every 19 seconds and one automobile death takes place every 13 minutes. These numbers are significantly higher than the 4,457 miners' injuries, which involve one injury every two hours, and 42 fatalities, one death every 9 days (Mine Safety and Health Administration, 2007). These misleading statistics cause people, as well as the government, to divert their attention to the high number of injuries that result from car accidents. Analysts view the statistics from different perspectives, including injuries per number of units and injuries per hour of exposure. Out of 201 million registered drivers in 2006, there were 84.6 injuries and two

fatalities per 10,000 cars. Out of 85,000 miners in 2006, there were 524.3 injuries and five fatalities per 10,000 workers. In comparing the amount of exposure, 188,990,182 employee hours were recorded, averaging to 2.4 injuries per 100,000 working hours (Mine Safety and Health Administration). The Federal Highway Administration recorded 2.7 trillion miles were traveled in 2006, which translates into 0.063 injuries per 100,000 miles traveled. While the average speed of drivers is unknown, an average speed range with a low of 15 miles per hour and a high of 50 miles per hour provides an estimate of about one to three injuries per 100,000 hours traveled. These comparisons provide a reason to give more attention to mining safety, but do not outweigh the problem of auto-related injuries and fatalities.

Whenever risk is involved, it carries a potential hazard. Hohenemser classifies hazards as “threats to humans and what they value.” Thus, hazards are measured by the amount of risk involved (Hohenemser, 1982). Without a standard method for calculating risk, certain activities may be viewed as more hazardous than more serious activities or products due to a misinterpretation of the level of risk. The ultimate question becomes: how is risk defined?

Risk can be interpreted via two methods: quantitative assessment and qualitative assessment (Marris, 1998). Quantitative assessment deals with how often accidents may occur. A person who views risk on a quantitative basis pays attention to risks that have higher injury or fatality rates, such as mining, even though there are a higher number of fatalities associated with automobiles. Qualitative assessment is based on dread of risk and an unknown rate of risk, rather than on any quantitative understanding of the number of people exposed to a particular risk. Dread risk is categorized by a lack of control of catastrophic potential; while unknown risk is determined by how unobservable or new an activity or technology is to a person (Slovic, 1987). This type of risk assessment is based on reactions from the general public, usually caused by widespread reaction to traumatic events that kill many people or have a negative impact on society. Since the September 11th attacks, many people have been more concerned about safety in airplanes, despite the fact that only one out of every 125,000,000 passengers dies annually (Health and Safety Executive, 2007). While this is not a standard measurement for rating risk, the statistic gives a general idea of how often people die due to aircraft accidents.

Slovic uses a psychometric paradigm to classify risk perception towards various activities and technologies. To demonstrate a psychometric paradigm, Slovic created a chart of how 40 members of the League of Women Voters, 30 college students, 25 business and professional

members of the 'Active Club', and risk experts (including a geographer, an environmental policy analyst, an economist, a lawyer, a biologist, a biochemist, and a government regulator of hazardous materials) perceive risk in several activities which could result in death, as shown in *Table 1*. These measurements are based on the status of the hazard in the form of controllability and knowledge, the possible benefits of a hazard, the average number of deaths per year, and the number of deaths caused in a year with a significant disaster. A risk value of one is considered the most risky and a risk value of 30 is considered least risky (Slovic, 1987). A rating of one to nuclear power, given by the League of Women Voters and college students, indicate that there is a high level of dread risk and unknown risk while experts only gave nuclear power a rating of 20 due to a low average number of fatalities per year. A government report entitled "Reactor Safety Study" done in 1975 supports the experts' analysis; this report estimated about 400 fatalities from a nuclear power plant meltdown as well as a meltdown occurring every 20,000 years (Cohen, 2003).

Activity or technology	League of Women Voters	College students	Active club members	Experts
Nuclear power	1	1	8	20
Motor vehicles	2	5	3	1
Handguns	3	2	1	4
Smoking	4	3	4	2
Motorcycles	5	6	2	6
Alcoholic beverages	6	7	5	3
General (private) aviation	7	15	11	12
Police work	8	8	7	17
Pesticides	9	4	15	8
Surgery	10	11	9	5
Fire fighting	11	10	6	18
Large construction	12	14	13	13
Hunting	13	18	10	23
Spray cans	14	13	23	26
Mountain climbing	15	22	12	29
Bicycles	16	24	14	15
Commercial aviation	17	16	18	16
Electric power (non-nuclear)	18	19	19	9
Swimming	19	30	17	10
Contraceptives	20	9	22	11
Skiing	21	25	16	30
X-rays	22	17	24	7
High school and college football	23	26	21	27
Railroads	24	23	29	19
Food preservatives	25	12	28	14
Food coloring	26	20	30	21
Power mowers	27	28	25	28
Prescription antibiotics	28	21	26	24
Home appliances	29	27	27	22
Vaccinations	30	29	29	25

Table 1: Psychometric paradigm sample

(Slovic, 1987)

These misconceptions of risk analysis can result in an inappropriate distribution of government funding. Slovic explains the reactions to disastrous events:

The impacts...sometimes extend far beyond these direct harms and may include significant indirect costs (both monetary and non monetary) to the responsible government agency or private company that far exceed direct costs (Slovic, 1987).

The United States Nuclear Regulatory Commission (USNRC) has a budget of \$917 million to protect the people and environment from hazardous nuclear materials (USNRC, 2007).

Compared to the CPSC's budget of \$63 million to oversee 15,000 products (CPSC, 2007), there is an obvious preference for mitigating risk involved in nuclear power plants as compared to mitigating the risk from lead paint in children's toys or exploding laptop batteries.

The mission of the Consumer Product Safety Commission (CPSC) is to regulate the hazards of various products from a quantitative perspective. The CPSC staff has various methods of minimizing the risks involved, ranging from recalls to regulations. Recently, the CPSC staff has been interested in examining and comparing injuries scenarios caused by HARAs including All-Terrain Vehicle (ATV) riding, skiing, SCUBA diving, and rock climbing. Although the causes of injuries in these HARAs are subjective, the CPSC believes that the risk is a result of behavioral and cultural factors.

Injuries have a major impact on the economy. A person's injury may result in a loss of his or her quality of lifestyle. In 1994, the economy lost a potential \$155 billion from work-related accidents. The value of a worker's life is estimated by their age, sex, race, occupation, employee benefits towards future payments and insurance, and experience (Biddle, 2004). A child or teenager losing a potential 50 years of life has a greater economic impact than a senior losing less than ten years, for example.

Often, technological benefits to society also cause problems. Hohenemser explains the costs and benefits of technology to society:

Even while recognizing that technology has been a principal contributor to increased life expectancy in the United States, [Hohenemser, Kasperson, and Kates] find that 20-30% of U.S. mortality can be associated with technological hazards and that the total cost of coping [with technological hazards] may be as high as 8-12% of the 1979 gross national product. (Hohenemser, 1985)

Economists use an estimate system that attempts to measure the benefits of technology to people against the costs that society may suffer from the technology. Kip Viscusi concluded that "most of the reasonable estimates of life are clustered in the \$3 million - \$7 million range" (Viscusi, 2000); the CPSC staff sets the cost of a life at \$5 million based on the average age and working ability of the population. If the cost of implementing new technology costs more than \$5 million, then the new technology will not be used due to the costs outweighing the benefits. Although this is a speculated science, poor estimates can lead to bad decisions. In 1972, Ford Pintos had a faulty gas tank, which could rupture and explode in a collision. An \$11-per-car improvement would prevent the 180 deaths caused by the gas tank fires. Secretary of Defense Robert McNamara argued that this improvement was not worth the cost based on his estimate of a human life set at \$200,000. It took eight years to prove his cost-benefit model was faulty. Experts failed to consider the hundreds of injuries caused by these fires. In addition, there was a

cheaper alternative to improving gas tanks, which would have only cost \$5.08 (Mark Dowie, 1977).

An example of cost versus benefits technology is automobiles. According to *Figure 3*, there has been a near-constant decrease in the rate of fatalities per 100 million vehicle miles traveled over a thirty year time period. These drops are a direct result of the Federal Motor Vehicle Safety Standards and Regulations established by the National Highway Traffic Safety Administration (NHTSA), which was enacted in 1968. These safety standards and regulations include brake hoses, seatbelt assemblies, fuel system integrity, and bumper standards (NHTSA, 1999). While the rate of fatalities per 100 million vehicle miles traveled has decreased, the total number of fatalities fluctuates. One of the drops was due to the required implementation of airbags in 1987. Airbags are estimated to have 15% effectiveness in preventing fatalities. Based on the economic value of a life, the actual value of the airbag, and the rate of occurrence of an automobile accident, the cost of a life saved per accident with an airbag is estimated at \$1.8 million. This high value indicates its cost of implementation to society, which is considered expensive if compared to the low cost and high value of seatbelts, about \$30,000 per life saved, using the same economic calculations (Levitt, 2001). Airbags also have a chance of causing other types of injuries. Between 1980 and 1994, 618 injuries have been recorded due to airbags, including damage to the face, upper extremities, and chest (Wallis, 2002).

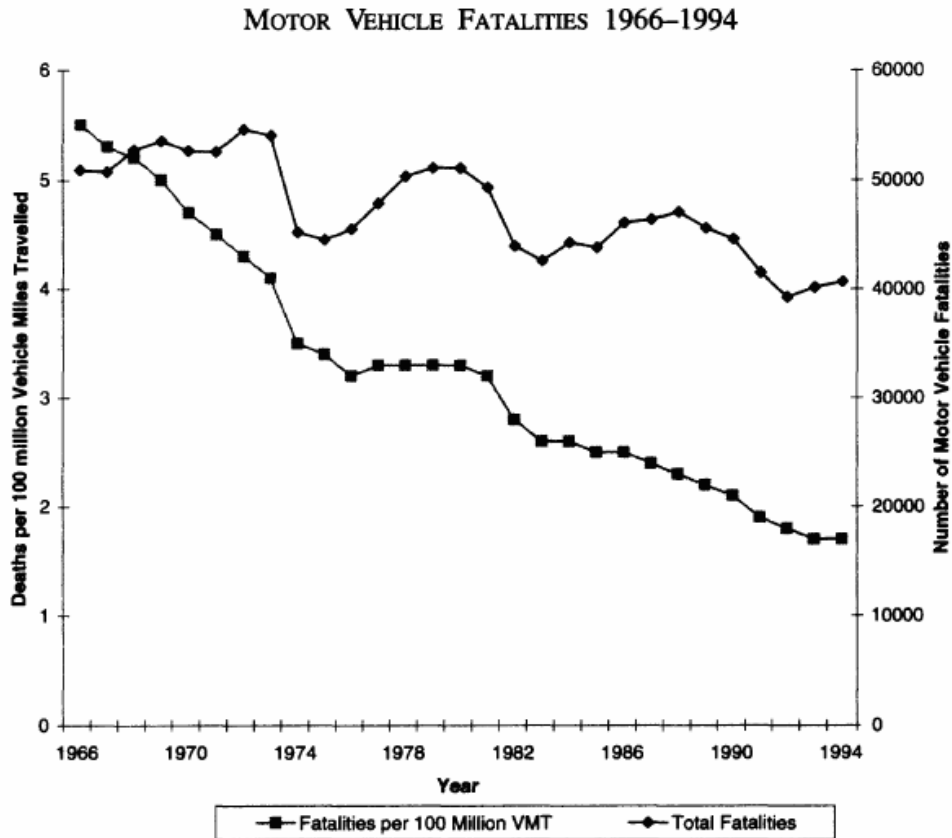


Figure 3: Motor Vehicle Fatalities

(Levitt, 2001)

2.2 Risk Management

“Hazard management is the purposeful activity by which society informs itself about hazards, decides what to do about them, and implements measures to control them or mitigate their consequences” (Hohenemser, 1985).

Hazard management involves society on several levels, from the individual citizen to government regulators. Individuals are the primary hazard managers. It is their responsibility to identify the hazards in their day-to-day lives and choose the best fit means to reduce or mitigate them. Between the individual and the government is the technology sponsor, who is usually a private firm that provides a good or service through technology. Technology sponsors generally create designs and provide information to the consumer to assist them in avoiding risk with their product.

The government’s involvement in hazard management can be divided into policy makers, regulators, and assessors. Policy makers include legislators on all levels of government and the

executive branch; regulators are officials charged with identifying and controlling hazards and assessors are technical experts who assist policy makers and regulators in their decision making. The unofficial watchdogs of the management process are consumer groups and the media. Consumer groups often focus on one or more industries, and lobby on behalf of citizens to ensure their interest is protected. The role of the media is the alert system of the public for managerial actions or policy failures. The media can influence the public by promoting discussion of some hazards while neglecting others.

The process of hazard management has two functions: intelligence and control (Kasperson, 1985). For hazard managers intelligence involves having both a prospective and retrospective viewpoint: prospective in that a manager must anticipate hazards before they can be realized and retrospective so that control measures can be evaluated. Control measures are aimed to prevent, reduce, redistribute, and/or mitigate the hazards (Hohenemser, 1985). The process of hazard control can be sequenced into hazard assessment, control analysis, strategy selection, and implementation and evaluation.

Hazard assessment has four steps: hazard identification; assignment of priorities; risk estimation; and social evaluation. The current methods for identification include research, engineering analysis, screening, monitoring, and diagnosis. The problem with focusing on scientific analysis is that it neglects mental health, social impacts, and political consequences. In certain cases it can result in information overload on certain topics and a severe lack of information on other topics. This is where assigning priorities comes into play. Managers have to decide between long term chronic hazards, or short term issues that have gathered political attention. After the hazard has been identified the next step is to estimate and characterize scientifically the probabilities of specific events and related consequences, and to evaluate this characterization in social terms (Hohenemser, 1985). The difficulty with this is that social estimates do not follow scientific estimates in many cases and uncertainty arises from the extrapolation of data when making a risk assessment.

After an assessment is made, control analysis judges the tolerability of the risk, and rationalizes the effort that is made in preventing, reducing and mitigating the risk. The criteria for determining the tolerability of risk are risk aversion, comparison to prevalent risks, cost-effectiveness of risk reduction, and a comparison between risks and benefits. Along with

tolerability, the equity of the risk, or how the risk is shared, is investigated among social groups, regions, and by generation (Kasperson, 1985).

The means of control can be explained through a seven step causal structure: 1) modify wants; 2) choose alternative technology; 3) prevent initiating events; 4) prevent releases; 5) restrict exposure; 6) block consequences; 7) mitigate consequences (Hohenemser, 1985). After choosing the means, the mode with which the control will be implemented will be decided. The modes of implementation are: mandate, where the law is used to regulate the product or its use; encouragement, or persuasion by providing incentives or penalties; and information, where those creating or suffering the risk are educated on how to reduce or tolerate the risk.

Education is the method that the government prefers to take when trying to persuade the public in matters of risk management. "Education refers to messages of any type that attempt to inform and/or persuade a target to behave voluntarily in a particular manner but do not provide, on their own, direct and/or immediate reward or punishment" (Rothschild, 1999). Education is the simplest form of risk communication, usually involving stating the end result of a risky activity as the persuasion not to do it. An example of this method would be anti-smoking ads with pictures of a blackened lung or of a person breathing through a hole in their throat.

The law is used when education cannot control an issue. Safety concerns about a risky activity could be communicated to the public, but the cost of not being safe is so high that the government intervenes in addition to the education. The other primary reason why the government chooses to use the law is when people know a risky activity is unsafe but continue to do it. An example of this is the seatbelt law; most people know that they should wear a seatbelt but many choose not to for personal reasons.

The method that the government employs the least is social marketing. "Marketing consists of voluntary exchange between two or more parties, in which each is trying to further its own perceived self-interest while recognizing the need to accommodate the perceived self-interest of the other to achieve its own ends" (Rothschild, 1999). In commercial marketing, the times between the two parts of a transaction are small and the benefits of the transactions are clear and agreed upon by both sides of the transaction.

Social marketing can be defined as "a program planning process that promotes the voluntary behavior of target audiences by offering benefits they want, reducing barriers they are concerned about, and using persuasion to motivate their participation in program activity"

(Rothschild, 1999). Social marketing is different from education, even though it can incorporate education. An example of social marketing is the public service announcements that encourage citizens to stop smoking. These public service announcements may include the hazards of smoking, support groups, as well as the benefits of quitting, such as longer life and more energy. As described by Rothschild, this program is trying to have people change their behavior voluntarily, offers the benefits of changing and uses them as persuasion, and reduces barriers to quitting by mentioning support groups. This method is avoided because it is the most difficult to accomplish. The government needs to inform the public of the risk, what they can do to lower the risk and the benefits the individual gains by lowering the risk. The problem with this method is that often the benefit is not realized until the long term, especially in health risk management. The potentially large amount of time until the consequences of the risk are realized makes it difficult for people to see the benefit, which can lead them to decide that taking the steps to reduce their risk are not worth the time, effort, or cost. The other barriers to social marketing include free choice, apathy, and inertia. What prevents Americans from changing is that they have made the personal decision, in addition to whatever social factors that may be involved on a case by case basis, to not take the time, energy, or cost to improve their lifestyle.

Table 2 provides a model to determine which method or methods of risk communication to use on people depending on three factors. These factors are ability, can the public afford to change their ways; opportunity, is there a readily available alternative; and motivation; are the people willing to change. For example, take the case for getting people to wear a seatbelt. All cars are equipped with seatbelts, giving the public the opportunity. The small amount of energy and time required to buckle up gives them the ability to use their seatbelt. The issue is that they lack motivation; whether it is that they feel a seatbelt is uncomfortable or wearing one is un-cool. Going to the model with this information reveals the public is “resistant to behave” and the best course of action is to implement a law, which in the case of seatbelts is exactly what has happened.

Applications of Education, Marketing, and Law

MOTIVATION		yes		no	
OPPORTUNITY		yes	no	yes	no
ABILITY	yes	① prone to behave <i>education</i>	② unable to behave <i>marketing</i>	③ resistant to behave <i>law</i>	④ resistant to behave <i>marketing, law</i>
	no	⑤ unable to behave <i>education, marketing</i>	⑥ unable to behave <i>education, marketing</i>	⑦ resistant to behave <i>education, marketing, law</i>	⑧ resistant to behave <i>education, marketing, law</i>

Table 2: Applications of Education, Marketing, and Law

(Rothschild, 1999)

There are methods that have been developed to assist in overcoming the obstacles to social marketing. The Environmental Protection Agency (EPA) uses the following seven steps in their risk communication (Public Health Service, 1995):

1. Accept and involve the public as a legitimate partner.
2. Plan carefully and evaluate your efforts.
3. Listen to the public's specific concerns.
4. Be honest, frank, and open.
5. Coordinate and collaborate with other credible sources.
6. Meet the needs of the media.
7. Speak clearly and with compassion.

The Center for Environmental Communication at Cook College developed the following ten questions that should be answered when communicating with the public about risk (Public Health Service, 1995):

1. Why are we communicating?
2. Who is our audience?
3. What do our audiences want to know?
4. What do we want to get across?
5. How will we communicate?
6. How will we listen?
7. How will we respond?
8. Who will carry out the plans? When?
9. What problems or barriers have we planned for?
10. Have we succeeded?

The third step in hazard management is selecting a management strategy which is aimed at four possible goals which are: risk acceptance; risk spreading; risk reduction; and risk mitigation. Risk acceptance may be achieved by providing compensation, as through higher wages for riskier work, or by seeking informed consent, as in informational or warning labels on hazardous products. Risk spreading seeks to transform a misdistribution of risk into a more equitable one through redistribution of the risk over social groups, regions, or generations. Risk reduction, in contrast to spreading or redistribution of risk, involves decisive intervention in the casual sequence of hazards. Lastly, risk mitigation includes a variety of ways of modifying hazardous consequences once they have occurred (Hohenemser, 1985).

The final stage of hazard management is implementation and evaluation. Ideally implementation would accomplish the management goals. The three factors that prevent implementation from occurring are that: 1) administrative resources are often inadequate, particularly in a decentralized system where lower administrative levels face large enforcement burdens; 2) those charged with health and safety control actions are often reluctant to do so because implementation conflicts with their own organizational and political interests; 3) hazard management strategies always contain implicit notions as to how hazard makers can be induced to take control measures. If the assumptions are wrong, the implementation fails. Effective management in the long term requires: 1) continued monitoring of control effects 2) reviewing the adequacy of control intervention in light of evolving knowledge 3) checking for the creation of new hazards (Hohenemser, 1985).

One type of chart that is used to characterize the steps involved with risk management is called a “hazard flow chart” (Hohenemser, 1985); as shown in *Figure 4*. This type of chart demonstrates what is known as the causal sequence; starting with human needs and ending with the possible human consequences. Through assessing the hazards, looking at possible controls, selecting a proper strategy, and implementing it at the proper stage, it is possible to eliminate or reduce the effects of a hazard on a society.

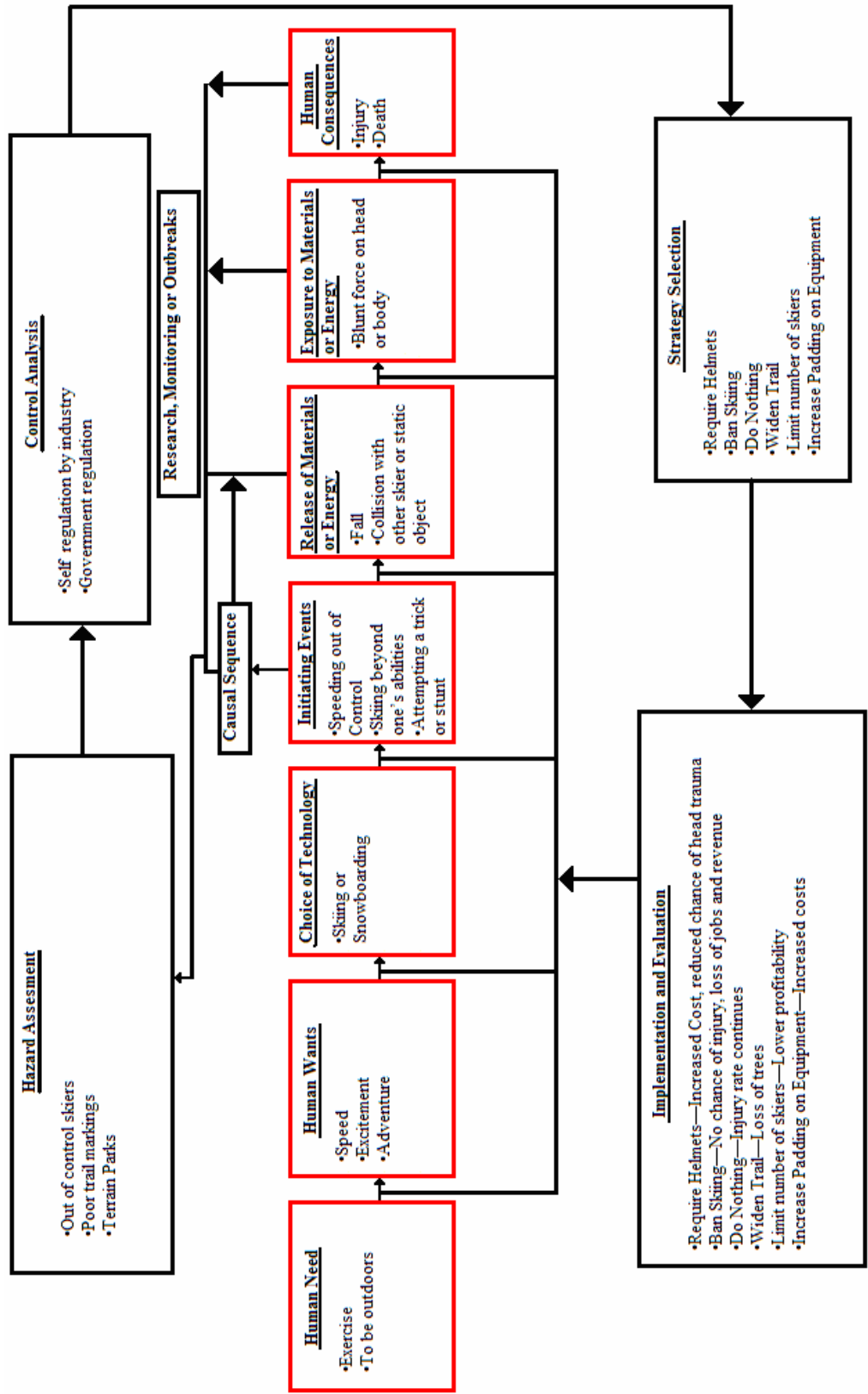


Figure 4: Hazard flow chart for skiing

(Hohenemser, 1985)

2.3 All-Terrain Vehicles

The popularity of high adventure recreational activities, especially riding All-Terrain Vehicles (ATVs), has grown substantially over the last few years. According to the Wall Street Journal, “Sales of ATVs...climbed 89% between 1997 and 2002,” and the business of producing ATVs is booming to “more than 3 billion dollars a year” (Fialka, 2004). These sales rates only represent a fraction of the total number of ATVs in use. The Consumer Product Safety Commission (CPSC) has developed a system to estimate the total number of ATVs in use by examining the amount of sales in a year and adding that to the estimated number of still functioning ATVs. These data are released in a yearly report entitled the *Consumer Product Safety Review*. This estimate is illustrated in *Figure 5*.

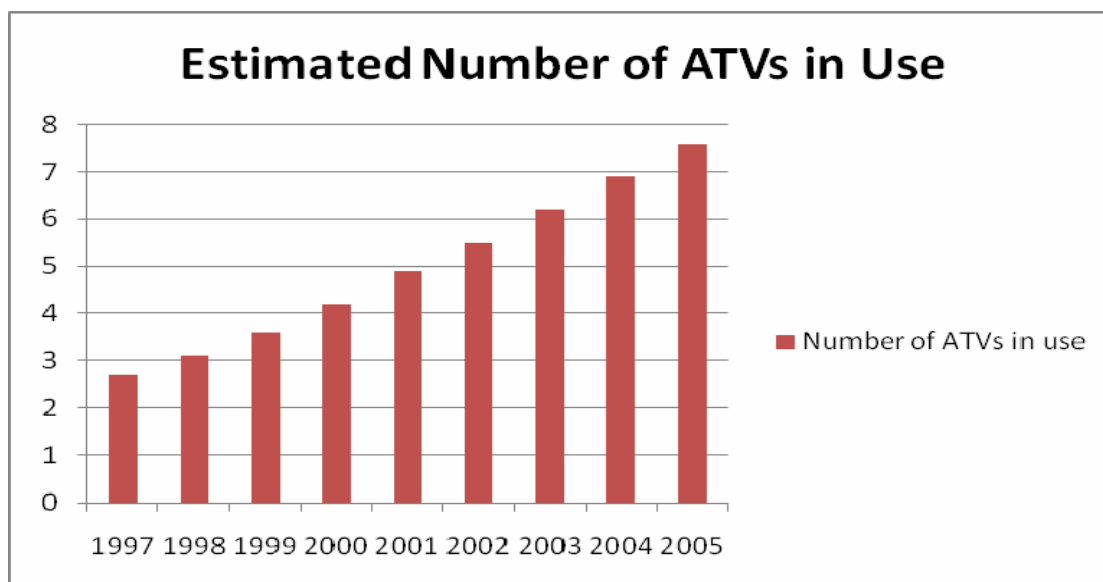


Figure 5: Estimated Number of ATVs in Use

(CPSC, 2005)

But there is a problem growing along with the rise in sales and popularity, which is the number of injuries and fatalities. The *Consumer Product Safety Review* also contains an annual ATV report that gives the total number of injuries and fatalities for that year along with statistics from other years for comparison. One example of the injury data given by this report is graphed in *Figure 6*, illustrating the increase in injuries over the last 10 years. This graph illustrates that there has been an increase in injuries for all ages, but the number of injuries for participants 24 and under has been increasing much more dramatically. Due to these data, the CPSC staff has decided to focus on this age group.

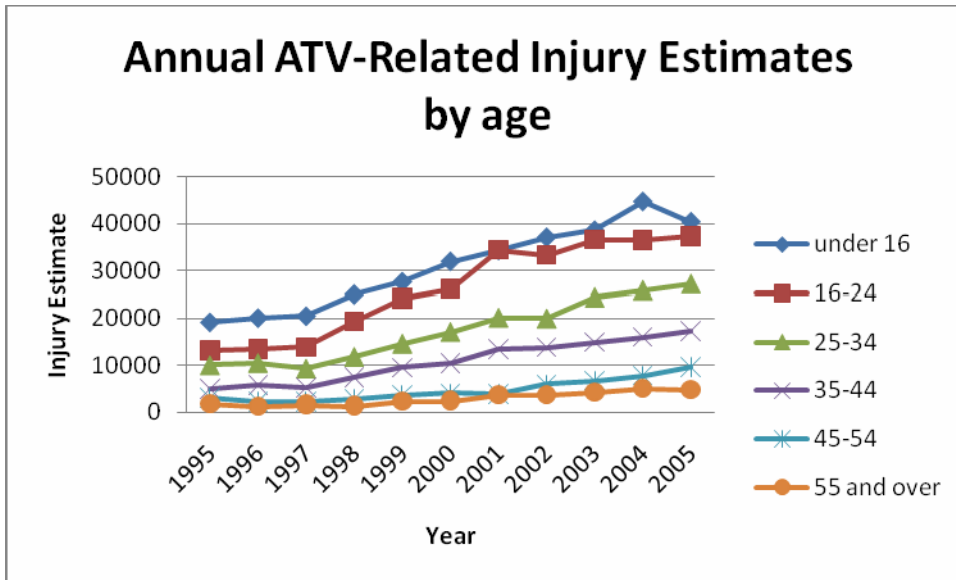


Figure 6: Annual ATV-Related Injury Estimates (CPSC, 2005)

By analyzing the injury and fatality data given by the annual ATV report, we were able to convert the number of ATV-related injuries and fatalities into a more usable statistic, the injury and fatality rates per number of ATVs in use. These rates are broken down by year so that comparisons can be made. See Figure 7 and Figure 8, respectively. There are many contributing factors that have led to the large and growing numbers of injuries and fatalities, such as age, sex, experience, and location.

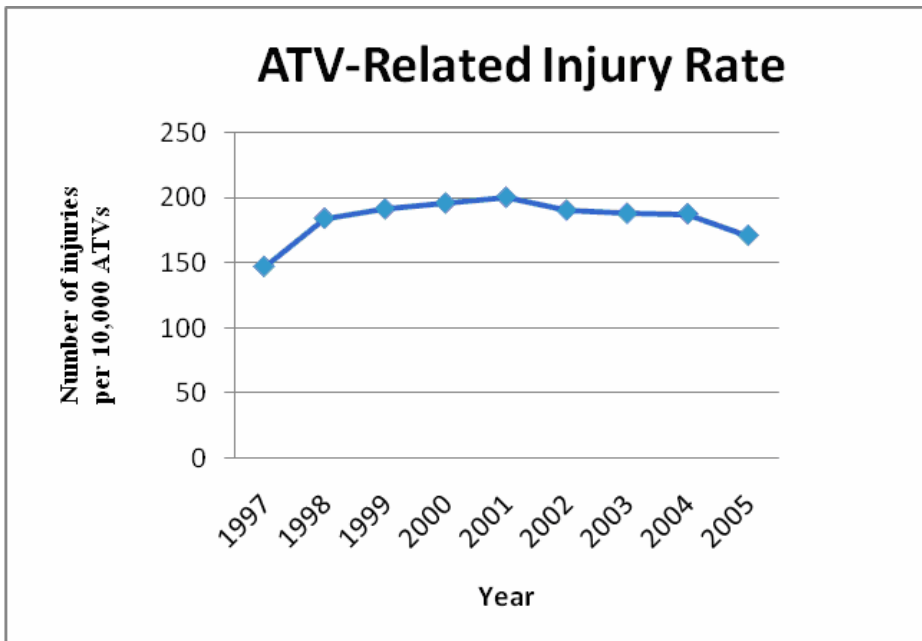


Figure 7: ATV-Related Injury Rate by Year (CPSC, 2005)

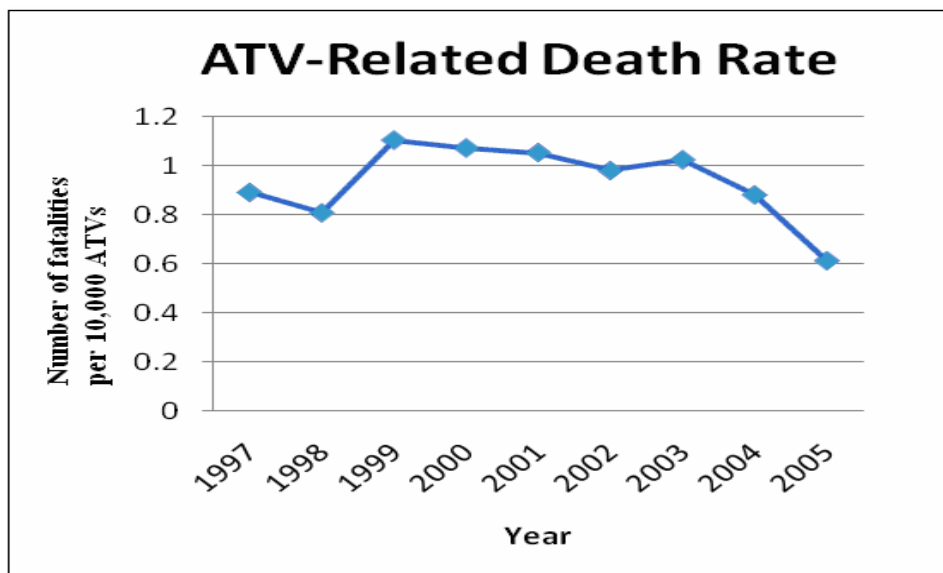


Figure 8: ATV-Related Death Rate by Year

(CPSC, 2005)

Legislation for ATVs have been introduced in many states, among them Pennsylvania, Kentucky, and Massachusetts. Some examples of regulations in these states are age restrictions, riding times, and mandatory helmet laws. These regulations are in place to protect participants in the activities, but they are not widely enforced because the laws are only applicable when operating an ATV on public land and have no jurisdiction on private property.

Children under the age of 16 make up around 31% of the people hurt while riding ATVs (Gittelman, 2006) and, since 1982, 2,178 children have been killed in ATV-related incidents (CPSC, 2007). This shows that 30% of the national deaths related to ATVs are suffered by those under the age of 16. Due to these statistics, many agencies, such as the American Academy of Pediatrics, have done extensive research in order to assemble the evidence necessary to demonstrate the causes of these accidents. The major factor was found to be the lack of physical and mental development in a child under 16. It requires a great deal of strength to safely maneuver an ATV, which on average weighs from 300 to 600 pounds. When these machines are not properly handled injuries and deaths occur. By the time a person reaches 16, his or her motor skills have matured to the point where these tasks can be performed with minimal efforts.

There is also a great amount of peer pressure during the adolescent ages of 11 to 21. Peer pressure is defined as young adolescents trying to distance themselves from their families in order to prove independence and form their own “peer groups” to replace their family (Gutgesell, 2004). These groups can have an immense effect on the members; possibly pushing members

into acceptance of levels of risk previously unknown to the person. This age group feels the need to prove themselves in order to gain new friends. In the context of ATVs, peers can be a dangerous influence and a contributing factor to the injury and mortality rate.

There are a variety of injuries involved with ATVs which range in severity from a cut, which requires little if any care, to a spinal column or head trauma, which could require thousands of dollars of medical treatment and result in a permanent disability. The most common injury of an ATV rider is a fracture, which makes up 45% of injuries (Shults, 2005). The type of injury also varies by age and sex. It was found that lacerations and facial injuries were most common in the 0 to 5 year old range and that children age 6 to 15 were more likely to sustain a lower trunk injury. It was also discovered that males age 11 to 15 make up 52% of the total emergency room visits involving children (Shults, 2005). This growing number of injuries has led the CPSC staff to take steps towards more regulations on the ATV industry in an effort to curtail this problem.

2.4 Skiing

Downhill skiing and snowboarding are popular recreational winter activities which are not without their share of risk. *Figure 9* shows the number ski area visits per season from different regions of the U.S from 1979 to 2007. The three regions that are visited the most by skiers are the North East, Rocky Mountains, and the Pacific West. Despite variations that may be due to seasonal conditions, the number of ski visits in each region has remained relatively stable over the past forty years, with the exception of the Rocky Mountain region which shows signs of growth.

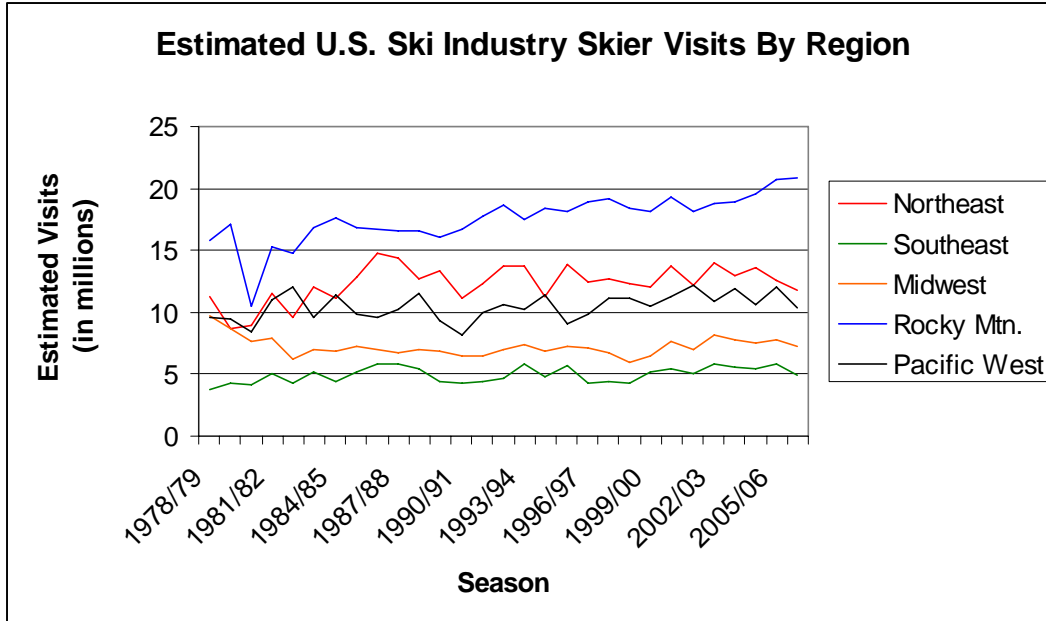


Figure 9: Estimated U.S. Ski Industry Skier Visits by Region (Source: NSAA, 2007)

Reflecting the trend in the regions, Figure 10 shows the total number of ski area visits in the U.S. since the 1978/79 season. The number of visits shows there has been little growth in the ski market.

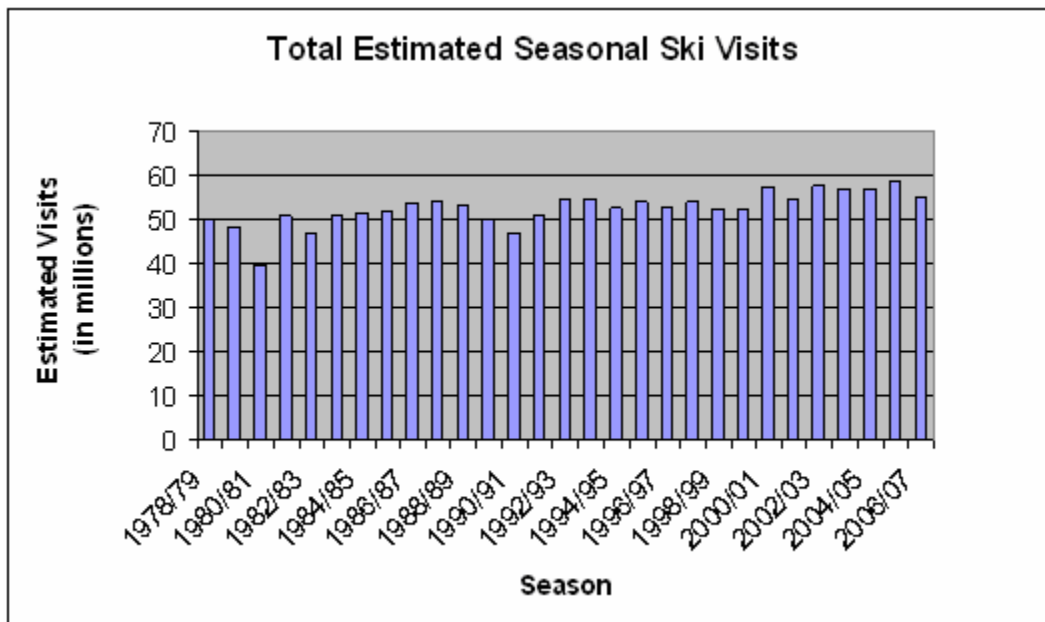


Figure 10: Total Estimated Seasonal Ski Visits

(Source: NSAA, 2007)

There are currently 485 ski resorts in the U.S.; 326 of them are members of the National Ski Areas Association (NSAA). Of the 485, 135 ski resorts operate in National Forests; these are large resorts which account for 55% of annual ski visits (CPSC, 1999). There are no state or federal laws that control skiers or snowboarders as to how they behave on the slopes. There is a simple code of conduct that is endorsed by the NSAA and is promoted by their safety campaign titled “Head’s Up”. The NSAA, along with the National Ski Patrol (NSP), the Professional Ski Instructors of America (PSIA), and Association for Snowboard Instructors (AASI), created the campaign to assist ski area operators nationwide address the topic of slope safety education for guests. “The initiative was launched during the 1999/2000 season and is continuing strong. The objective of the campaign is to attempt to further reduce the frequency of accidents and to unify the industry to focus on and communicate a proactive, strong safety message”. The NSAA “recognizes that there are inherent risks to skiing and snowboarding.... and how it is important to keep the risks of skiing and snowboarding in perspective and communicate how personal responsibility is key” (NSAA, 2007). The code of conduct is posted at every NSAA member resort and is as presented below (NSAA, 2007):

1. Always stay in control.
2. People ahead of you have the right of way.
3. Stop in a safe place for you and others.
4. Whenever starting downhill or merging, look uphill and yield.
5. Use devices to help prevent runaway equipment.
6. Observe signs and warnings, and keep off closed trails.
7. Know how to use the lifts safely.
8. **KNOW THE CODE. IT'S YOUR RESPONSIBILITY.**

While any resort official can enforce their regulations, on the slopes enforcement is most commonly done by the mountain’s ski patrol. Members of ski patrol are either volunteers or paid employees who have been trained and certified by the National Ski Patrol. Skiers and snowboarders who break this code can be penalized in a variety a ways, from being required to view an informational video to being removed from the mountain for a period of time.

One cause of skiing accidents is collision with other skiers. *Figure 11* displays the number of ski resorts since the 1984/85 season. This number has decreased steadily since records began being kept in 1984. This means that even though the number of ski visits has

remained stable, there are now more people on the slopes due to the reduced number of resorts. The number of collisions would be thought to increase as well, but the NSAA reports that it has remained stable over the past 30 years.

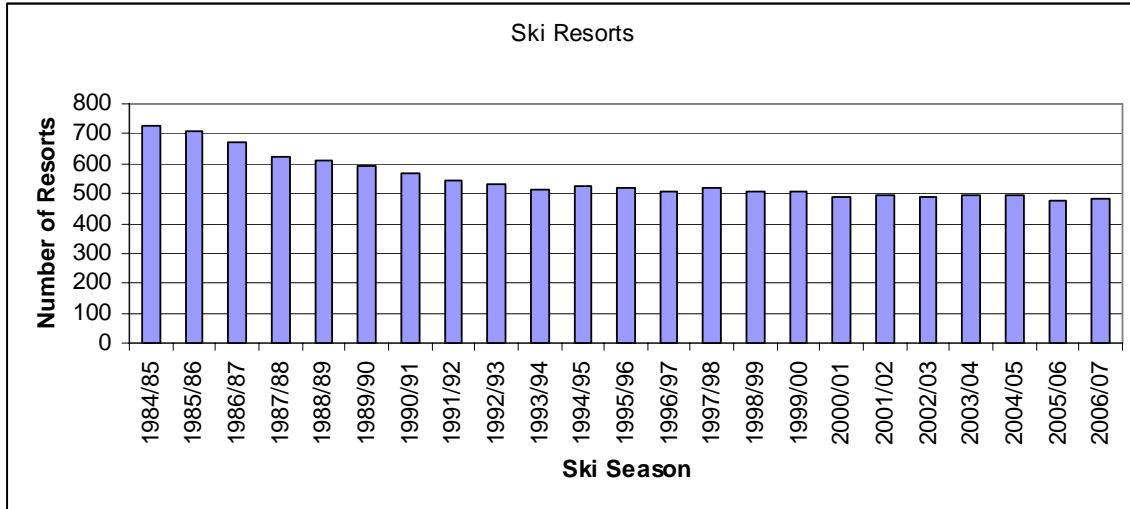


Figure 11: Number of Ski Resorts

(Source: NSAA, 2007)

Ski resorts routinely offer instruction to new skiers and lessons for more advanced skiers who want to improve. Instructors are certified through the Professional Ski Instructors of America (PSIA). Instructors receive a level of certification, I, II, or III, with III being the highest based on their skiing experience, ability, and knowledge of the industry. There is no certification process for those learning to ski at a resort. Skiers are informally broken into three categories; beginner, intermediate, and expert. This is determined by what level of trail they ski. All American ski resorts use the same rating symbols: green circle for beginners; blue square for intermediates; black diamond for experts. These standards do not translate precisely between ski resorts because there is no standard as to how trails are rated due to geographic differences among the various mountains.

The injuries suffered by skiers range from blunt trauma to more serious head injuries. A Denver-based neurosurgeon, Dr. Levy (2002), writes that his facility saw 1,214 patients admitted for all types of injuries related to skiing and snowboarding from 1982 to 1998. Sixteen of the 1,214 patients died, and head injury was the cause of death in 14 of them, that's 88% of ski deaths due to head injuries (Bortz, 2007).

In another study period, from 1980–2001, 149 fatal injuries associated with downhill skiing were identified nationally; 21 (14.1%) occurred among child skiers aged 17 years or younger. The age of the youngest decedent was 7 years. In females the proportion of fatal injuries among child skiers was nearly three times that of adults. Traumatic brain injuries were the leading cause of death (67% of all deaths) among children, while multiple internal injuries and traumatic brain injuries accounted for almost equal proportions of fatal injuries among adults. Collisions with other skiers or snowboarders were the leading external mechanism of fatal injuries, accounting for more than two thirds of fatal injuries in both child and adult skiers (Bortz, 2007).

In an American Medical Association (AMA) study over a period of 15 ski seasons (1981 to 1997), a total of 11,795 injuries were diagnosed among skiers at Sugarbush, a major Vermont ski resort. Three hundred and nine people (2.6%) were diagnosed as having Potentially Serious Head Injuries or PSHI. Three people (1% of PSHI cases) died, 10 (3.4%) had skull fractures, 8 (2.6%) had severe brain injuries, and 288 (94%) suffered concussions. Because there were 4,322,589 skier visits during the 15 ski seasons, the overall incidence of ski injuries was 2.7 per 1,000 ski visits, while the incidence for PSHI was 0.07 per 1,000 ski visits. These figures can be compared with results from the study of ski injuries that occurred at the Mammoth-June ski resort in California. In this study, the overall injury rate was 2.6 injuries per 1,000 ski visits, while the rate of head injuries was 0.24 per 1,000 ski visits (AMA, 1997).

From 1993 to 1997, the estimated number of hospital emergency room-treated injuries associated with skiing declined from 114,400 to 84,200 nationally (CPSC, 1999). 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 while the number of snowboarders increased from 1.8 million to 2.8 million (NSAA, 2007). The rate of injury increased from 0.7% to 1.3% of snowboarders being injured. 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 (an estimated 4,950 head injuries annually) (CPSC, 1999). The 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. The data were examined by the CPSC staff to identify the frequency of head injury in these fatalities. This review revealed that 108 of the reports, or more 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 (CPSC, 1999). This chart shows that the most likely candidates for a head injury related death are skiers between the ages of 25 and 44.

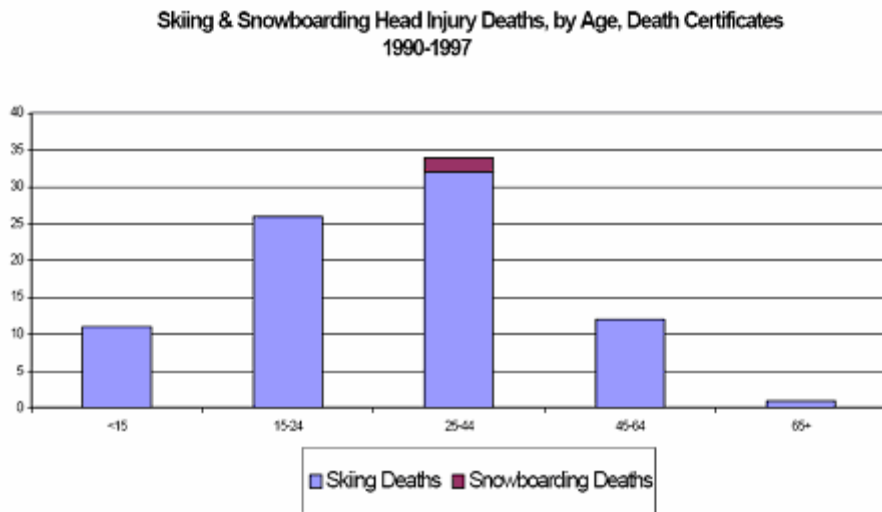


Figure 12: Skiing & Snowboarding Head Injury Deaths, by Age, Death Certificates (CPSC,1999)

The NSAA reports that helmet utilization in the U.S. has increased by about 5 percent per year for the last several years. In the 2006/07, season the overall usage of helmets among skiers and snowboarders was estimated to be 40 percent, up from 38 percent the previous season. “It was higher among children nine and under at 64 percent; 10 to 14 year olds at 56 percent; adults aged 55 to 64 and 54 percent. Helmet usage is lowest among 18 to 24 year olds at 26 percent” (NSAA, 2007).

Helmets for skiers and snowboarders have been promoted by the NSAA as a way to lower the risk of head injury. The NSAA, in cooperation with others in the ski industry, developed the Lids on Kids campaign in 2002 (NSAA, 2007). “The [Lids on Kids] site contains FAQs about helmet use, fit and sizing information, general slope safety information, related articles and games, and testimonials about helmet use from well-known athletes, including US

Ski Team members. The site has received nearly 2 million hits since it was created. The tagline, “A Helmet-It’s a Smart Idea,” is printed on posters and promotional cards at resorts nationwide” (NSAA, 2007).

Presently, no state has made the wearing of helmets mandatory for any age group. Ski resorts recommend them for younger skiers and in most cases will rent helmets if a family doesn’t want to make a purchase. The magnitude of risk reduction for the more severe injuries (i.e., moderate-to-severe concussion, skull fracture, etc), is likely to be small because most skiers travel at speeds in excess of 20 mph and the proposed American Society for Testing and Materials standards for ski helmets likely would offer full protection only at speeds up to 12 mph (AMA, 1997). Even if some injuries occur at higher speeds, the helmet will likely still provide some protection and reduce the severity of the injury. The degree of change in injury rates that can be brought about by a helmet can be seen by viewing bicycle helmet data. Impact velocities specified in various bicycle helmet standards range from 10 mph to about 14 mph. A 1989 study found that bicyclists with helmets meeting established standards had an 85 percent reduction in risk of head injury, and an 88 percent reduction in risk of brain injury (CPSC, 1999).

2.5 Scuba Diving

SCUBA diving has become a popular activity over the last several years. The total number of dives recorded by the Divers Alert Network (DAN) is a representation of only 8,000 divers; the Project Dive Exploration (PDE) is used by DAN to record the dives performed by a set number of SCUBA divers (Divers Alert Network, 2006). According to *Figure 13*, the number of recorded dives by these divers has increased to an estimated 100,000 dives in 2004, about 13 dives per diver. In addition, Diana Richards believes there are millions of active SCUBA divers doing millions of dives a year, as well as another 500,000 newly certified divers annually (Richards, 2004).

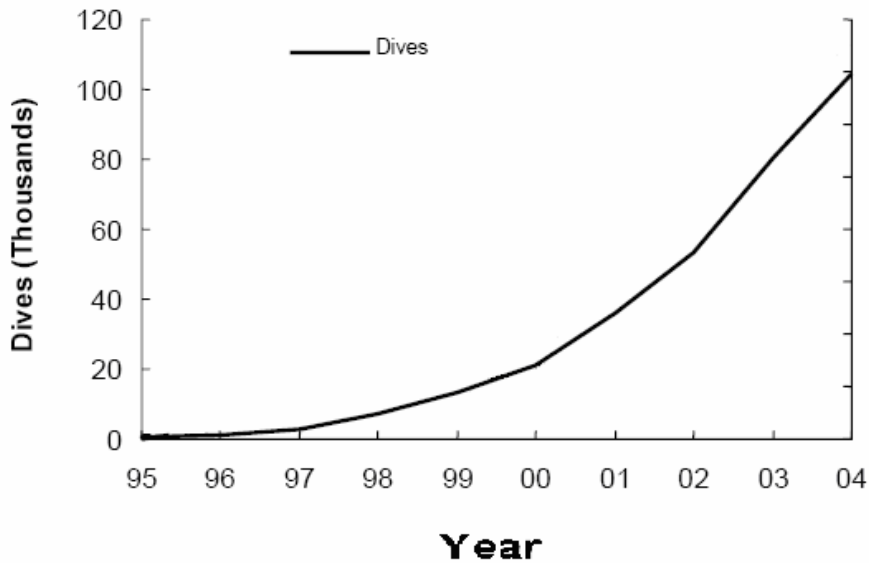


Figure 13: Number of SCUBA dives per year (Divers Alert Network, 2006)

Figure 14 shows the number of SCUBA related injury cases since 1987, when DAN started to record data on injuries. According to the reported data, DAN’s estimated rate of injury in 2004 was 50 injuries for every 10,000 dives. The drop of notified and reported injuries in 2003 represents the effects of the Privacy Act issued from the Health Insurance Portability and Accountability Act (HIPPA), restricting access to medical data from patients of SCUBA related incidents. The Privacy Act had a greater affect on SCUBA diving records due to a lower number of incidents compared to other activities. This drop was countered in 2004 with the improvements of the Medical Services Call Center (MSCC), “[allowing] medics, physicians, chambers, and evacuation services in different geographic locations to communicate quickly over the Web and so improve the speed and safety with which injured divers are triaged and delivered to care” (Divers Alert Network, 2006). The MSCC also improved the accuracy of reported incidents.

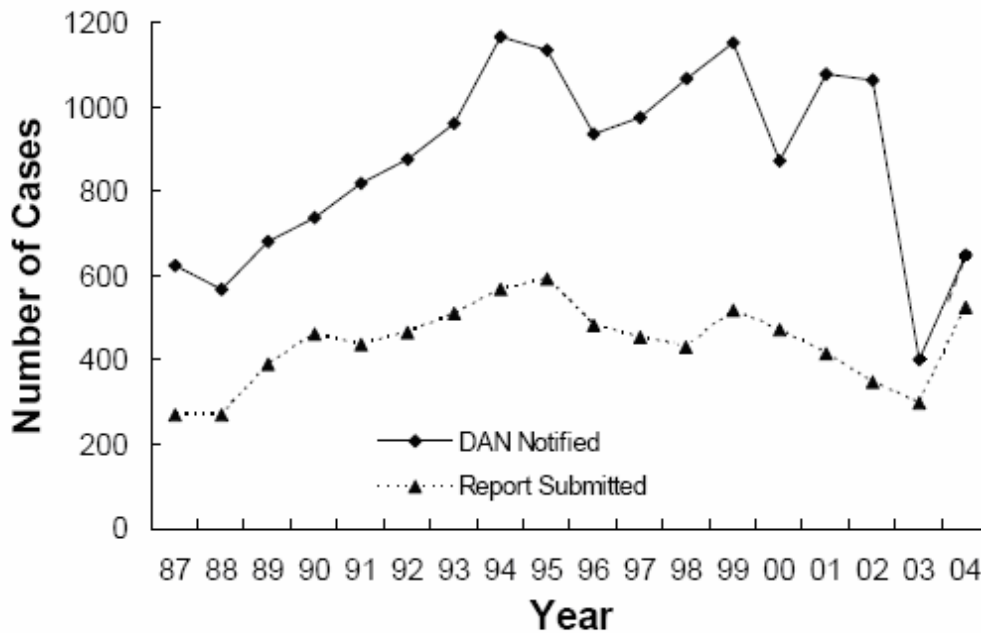


Figure 14: SCUBA diving related Injuries by year (Divers Alert Network, 2006)

At least 80% of all SCUBA injuries occur within the head and neck area. The most common injury associated to SCUBA diving is a variation of barotrauma, called middle ear barotrauma (MEB). MEB occurs in 30% first time divers and 10% experienced divers (Clenney, 1996). Barotrauma is caused by an irregular change of increasing or decreasing pressure. Divers are trained to moderate their rate of elevation and depression to avoid barotrauma. Although most barotrauma cases occur within the ear, it can also affect the lungs, which is a more serious problem. In a situation where a diver must reach the surface of water due to the depletion of air, lung tissue will rupture. This is the leading cause of death in SCUBA diving (Degorordo, 2003). The best method to prevent any type of barotrauma is to slowly approach the surface, continuously breathing. By diving with a partner, this situation can be avoided by sharing one tank of air in the event that the other tank failed.

As opposed to other high adventure recreational activities, SCUBA diving requires a certain amount of training to be able to perform a dive. Organizations, such as the Professional Association of Diving Instructors (PADI), help train and certify people. To earn a basic level of certification, the participant must have knowledge of how pressure affects the body and knowledge about optimal gear as well as pass an exam assuring a designated level of knowledge.

After passing the exam, the participant then practices diving in confined water dives to practice techniques including setting up gear, sharing air, and getting rid of water in a mask. This process can take anywhere from three days to six weeks, depending on the how often the participant meets with an instructor (PADI, 2007). Outside of basic and advanced levels, there are other types of certifications for specialized areas of diving, including deep diving, dry suit diving, enriched air nitrox diving, rescue diving, search and recovery diving, and underwater focus diving (archaeology, ecology, environmentalism, photography) (NAUI, 2005).

In addition to required training, SCUBA diving is a self-regulated activity. Training has been a concern since the 1950s, when sports director Al Tillman and lifeguard Bev Morgan created the Underwater Instructor Certification Course, providing training to the public. The National Association of Underwater Instructors (NAUI) was later created in 1960 as a non-profit organization, dedicated to educating SCUBA participants. The New Jersey Council of Diving Clubs is an example of a self regulated organization. The New Jersey regulations include marking the diving position with a buoy flag at the water surface, not coming within 50 feet of another dive group's buoy flag, not diving below 25 feet of the buoy flag, and not diving in narrow or confined areas. Due to a lack of data on individual state injury statistics, it is difficult to judge the effectiveness of state clubs.

Proper training and preparation for SCUBA diving takes time. Unfortunately, PADI, as well as other associations, does not require a refresher course if a participant has not gone diving in several years, even though they are offered. According to *Figure 15*, DAN has estimated that 25% of injuries are divers of lower than a basic certification, 30% of injuries are divers with a basic certification, and 35% of injuries are divers with advanced certification (Divers Alert Network, 2006); divers without a specialized degree of certification compose 90% of all injuries. While the total number of divers and diving frequency of each certification category are unknown, DeGorordo attributes the majority of SCUBA injuries to an improper training method (Degorordo, 2003). Richards also identifies the problems of dives issued by high end resorts. Because the divers "...receive minimal training [and] do not require a doctor's medical clearance..." the chances of an injury or fatality occurring are higher (Richards, 2004).

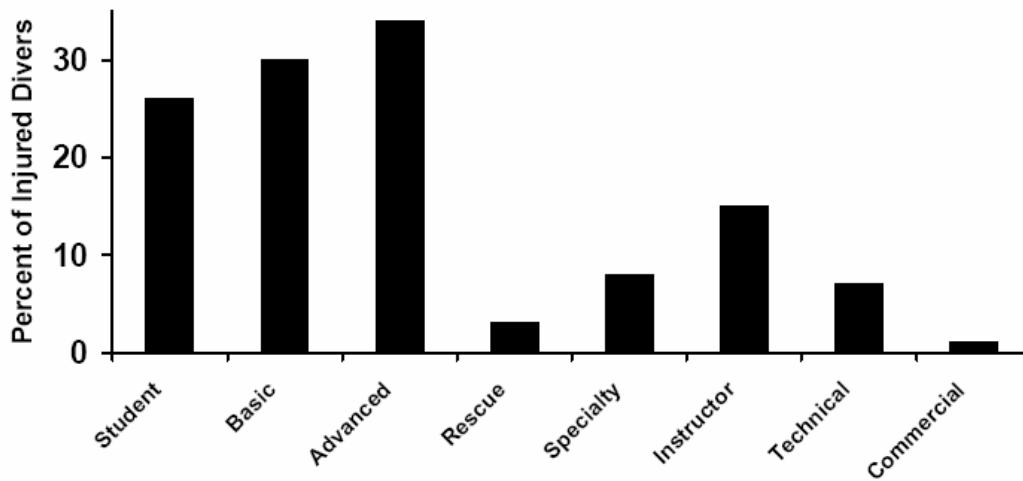


Figure 15: Injured Divers and Certification Level (Divers Alert Network, 2006)

Figure 16 represents the number of fatality cases in SCUBA diving since 1970. The most significant improvements in decreasing the rate of injuries and fatalities have been due to advancements in technology. An example of this is the dive computer, introduced in 1983. This device determines which areas are safe to dive in, the radius of the area that is safe, and the timeframe of safety (Diving History, 2007). As represented in *Figure 16*, its implementation helped decrease the overall number of fatalities after 1984. Unfortunately, DAN has discovered that this technology is also responsible for 80% of SCUBA related injuries. Strauss believes these injuries are due to the belief that the dive computer is a perfect machine, and sometimes reliance on the device can override a diver's judgment (Strauss, 2001).

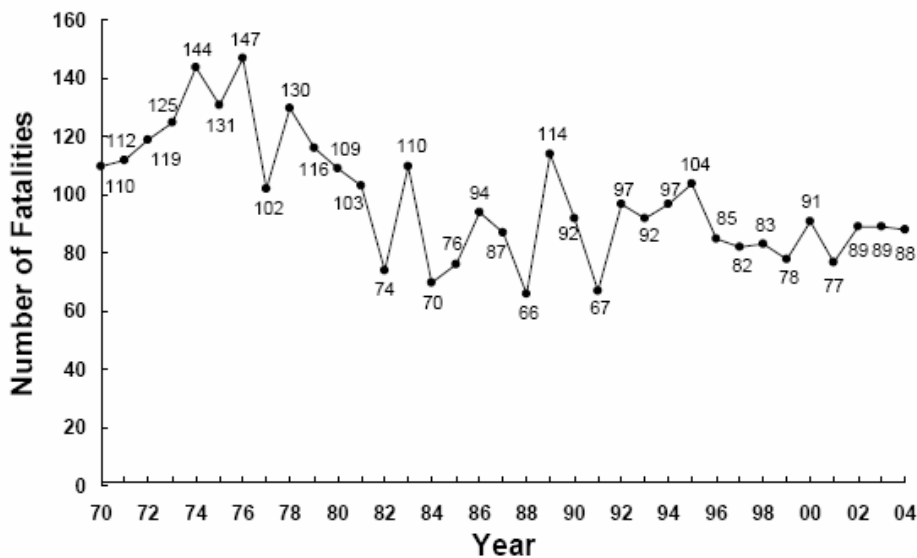


Figure 16: SCUBA Diving-Related Fatalities

(Divers Alert Network, 2006)

2.6 Rock Climbing

Recreational rock climbing has developed into a pastime for some 100,000 people in the U. S. alone, but this activity is not without its risks. These risks include those resulting from weather conditions (not only at the beginning of the climb but at the end), possible rockslides/avalanches, which are uncontrollable by humans, and risks dependent upon the particular safety system used. There are also a variety of human factors including training, physical preparation, location, and equipment failure.

The technology of rock climbing has been changing in order to make this sport as safe as possible. One development that made climbing safer was the development of the “top rope system” (Williams, 2003). This system lowers a rope from the top of the rock/wall and hooks into a safety harness securely attaching a climber to the wall. This technology has significantly reduced the number of life-threatening falls. In order to make sure that safeguards, such as carabineers, harnesses, and helmets are safe, the American National Standards Institute (ANSI) has set up a series of regulations for this equipment. One example of this is the Standard Specifications for Climbing Harnesses (ASTM F1772-99, 2005), which gives specific instruction on the testing, labeling, and marking of harnesses to ensure a participant’s safety.

Another safeguard that has been put in place to protect participants is the difficulty scale developed to compare different climbs. There are a variety of systems used to determine the difficulty of a climb. The most popular system classifies the mountain into three different categories which are: 1) Grades, which explain how long it will take to make the climb; 2) Classes, which determine the techniques necessary for the climb such as hiking, scrambling, steep, and also tells if ropes are necessary; and 3) Danger Ratings, which tell the amount of run-out (rope length from one anchor point to the next) and the risks involved in failed equipment. The combination of these three categories will allow a climber to judge if he/she will be able to make the climb safely. The problem with these systems is that they are highly subjective. For example, an experienced participant could climb a Grade IV, long day, climb in just a few hours, thus making it then a Grade I or II for him or her (ASCA, 2003).

These classification systems are well suited for outdoor climbing, but not very well for indoor climbing. The reason for this is that these indoor walls do not erode or change over time. Indoor climbing walls have grown in popularity due to their safety features, stable weather conditions, and a large variety of climbs in one place. Many sports complexes have added climbing gyms that allow their members to do both bouldering, hiking with a little bit of scrambling in order to reach the top of a boulder, then jumping, and climbing, giving participants a year round place to practice and refine their skills.

Rock climbing schools not only educate those who are new to the sport, but help more experienced climbers to hone their skills. Experienced climbers take additional courses so that they can become certified as a guide by the American Mountain Guides Association (AMGA). This organization is guided by the international guiding requirements set forth by the International Federation of Mountain Guides Association (IFMGA) which require different levels of training for guides depending on the type of terrain. The AMGA offers six different courses starting with a basic guide training called single pitch, to a much more complicated and in-depth course that certifies a participant as a Rock Guide. A single-pitch guide is certified to only take people on climbs with an anchor/stopping point, known as a pitch, where the lead climber would belay the people below to the pitch and then back down, but they are not allowed to go above this point. Rock Guides are certified to lead people on any type of climb. These courses allow a climber to develop his or her skills in climbing to the point where he or she is able to properly teach and demonstrate the skills needed for a particular climb. These courses

are very in depth and take an average of 10 days to complete. In advanced courses, such as the Rock Guide course, an additional test must be passed that can take up to six days to complete (AMGA, 2007). At the end of this training, the participant will be internationally licensed to lead climbing expeditions and train new climbers.

The basic training courses teach new participants many of the skills necessary to climb such as: knot tying, identification and use of safety gear, and basic techniques. As with the instructor courses, a participant can learn many advanced techniques under the supervision of an instructor. Two examples of when special training would be needed are “Trad climbing” and “Trad leading”. Trad climbing is scaling a wall with no permanent anchors. The anchors are put in place by the “Trad leader” who is the first person up the wall. To become a Trad leader, a climber must learn how and where to place the non-permanent anchors, which are called cams, to make sure they will not pull out. This is an important job because the failure of these anchors could cause a fall and could cause injury or even death. There are many other types of climbing that require special training and special skill such as ice climbing, free climbing (without ropes), and many others, but these are all extreme realms of the activity and require expert climbing skill.

2.7 Voluntary Standards and Notice of Proposed Rulemaking

The Consumer Product Safety Commission (CPSC) has jurisdiction over about 15,000 consumer products. They are in charge of investigating what problems these products have caused, understanding why the problem occurred, and taking preventative action to stop these incidents from happening again. There are two preventative measures that the CPSC staff uses when dealing with a product that has been deemed “hazardous”: voluntary standards and rulemaking, which is the creation of a new law. Since 1990, the CPSC has released 38 mandatory regulations (CPSC, 2007). These options allow the agency to better regulate or control the hazardous products to prevent injuries.

Voluntary standards are given to manufacturers in order to make their products safer. When the CPSC staff has a concern with a product, they will write a letter to a standards coordinating organization stating their concerns as well as providing death and injury data related to the product. These standards are then developed by many different agencies such as the American Society for Testing and Materials (ASTM) that deals with children’s products,

Underwriters Laboratories (UL) that deals with electronic products, and the American National Standards Institute (ANSI), which deals with a variety of products. These agencies are non-profit groups that work to promote a variety of different programs and standards to reduce the risks involved with consumer products. These agencies are typically overseen by a board of experts in industry, engineering, law, manufacturing representatives, and a member of the CPSC team who holds a non-voting seat on all committees. This representation allows the CPSC staff to explain the results of their findings with the faulty product and what ways they have investigated to solve the problem. These suggestions could be to increase the number of warning labels or to redesign the product to make it more user-friendly.

Once these standards are verified by the respective agency, it is then in the hands of the manufacturers to decide to apply these standards or not. One example of a voluntary standard is the “Voluntary Standards for Four-wheeled ATVs Act” (CPSC, 2007). These standards are strictly enforced by some manufacturers and completely ignored by others because they are not required by law. If a company has the standards in effect and a dealer violates them, the manufacturer is in charge of punishing the dealer. This punishment could be a minor fine or could mean the loss of the right to distribute that manufacturer’s product. When these standards are not effective in reducing injury and fatality rates, the CPSC staff moves forward to rulemaking.

Rulemaking is the creation of regulations and laws when voluntary standards have not proven effective. Rulemaking can only occur if there is already a voluntary standard in effect for the product of concern (CPSC, 2007). In order to create a mandatory standard, the CPSC’s Engineering Sciences department, which is comprised of mechanical, electrical, fire safety, and human factors engineers, must first do background research and testing in order to identify problems with a product. Secondly, the economics department must develop an injury/fatality cost model. This model illustrates the amount of money that product failures have cost in terms of medical bills, repairs, pain and suffering, and how much money would be saved by changing the product or enacting some other type of mitigation strategy. The CPSC staff then prepare a Notice of Proposed Regulations (NPR). This is a report released to the public stating their findings and recommendations that they plan on proposing to the Commission. This report is used to “seek input from all interested parties, including consumers, industry, and other government agencies”. After a period of time, the NPR is then brought to the Commission for

their approval. If the Commission votes to create the regulation then it becomes federal law and all related products being sold must comply. One example of a regulation is performance standards. These standards are developed by the CPSC staff to allow manufacturer flexibility in the design of the product (CPSC, 2007).

There are several advantages to using voluntary standards over rulemaking. One advantage is that voluntary standards save money. Because the standards coordinating organization is involved, the CPSC only has to pay for the technical support of the voluntary standard. Mandatory standards force the commission to pay for everything related to the process of issuing the standard, including testing and laboratory use. Another advantage of a voluntary standard is its efficiency in time; mandatory standards require several reviews, justification, as well as a cost-benefit analysis.

2.8 Literature Review Summary

The Literature Review provided the knowledge base for our future research. Risk theory and management explained how risk is considered and how it can be mitigated. The status of each activity was detailed in their own section, with information on current risk factors and ongoing mitigation strategies. The voluntary standards process described how the equipment in these activities can be regulated. The outcome of this research is reflected by sections that follow.

3 Methodology

The Consumer Product Safety Commission (CPSC) has witnessed an increase in the injury and mortality rates associated with certain high adventure recreational activities (HARAs). Our goal was to advise the CPSC about the factors that contribute to the risk in these activities, how they are currently being mitigated in each activity, and determine if mitigation strategies that are effective in one activity could be applied to the other activities that were investigated. By devising a classification system we were able to derive strategies for risk management associated with four HARAs which were: All-Terrain Vehicle riding (ATVs); skiing; SCUBA diving, and rock climbing.

This goal was accomplished through four strategies. First, our team began by looking at the patterns and trends illustrated by the injury and fatality data associated with these HARAs. Second, our team researched risk management strategies used in each activity as well as other related activities. Third, a behavioral analysis of participants in each activity was conducted to see if any correlations existed between the psychology of the participants and the number of injuries that occurred. Lastly, our team synthesized the findings from the analysis of the injury data and risk management options and formatted recommendations for the CPSC.

In order to accomplish these objectives, multiple data gathering strategies were implemented. Our team analyzed the CPSC's databases to identify possible trends and patterns regarding injuries and fatalities in HARAs. We researched various methods of risk mitigation and identified which were successful in other activities. Interviews and surveys were conducted with representatives of various trade associations and user groups, including participants in HARAs.

3.1 Injury and Fatality Data

The first resource that was used while in D.C. was the electronic databases provided by the CPSC staff. These databases include the National Electronic Injury Surveillance System or NEISS, In-Depth Investigation or IDI, news clip, and hotline databases. These four databases gave a variety of information such as injury and fatality statistics, in-depth reports of the scenarios surrounding incidents, and what consumer products were involved. These databases allowed our team to compile injury data for the selected activities by region, age, race, sex,

severity of injury, body part injured, and many other factors that could have affected these incidents. In order to do this it was necessary to generate a classification model.

3.1.1 NEISS

The NEISS database was the primary statistical resource used during the investigation. This database consists of short reports provided by hospital emergency rooms. There are currently 100 hospitals across the contiguous U.S. that report injury data to NEISS. These hospitals were selected based on their size, location, and demographic of the local population. Appendix F contains a map of NEISS hospital locations, as of 2003. The reports generated by the hospitals contain information on a patient's sex, race, age, date of injury, type of injury, location of injury, and level of hospitalization. From the set of reported injuries, the NEISS database will generate a historical estimate for the number of injuries from a product or activity for the entire nation. Every estimate generated by the NEISS database is accompanied by a coefficient of variance or CV. The CV of an estimate, which can be calculated using *Equation 1* which can be found in Appendix G, is dependent upon the number of reports entered into the NEISS database. This means that the CV is different for each of the activities, and for each NEISS estimate within a particular activity. Thus, a NEISS estimate of ATV head injuries will have a different CV than a NEISS estimate of ATV knee injuries. This is the reason why there are few graphs comparing different activities on the same graph. In addition to being able to make injury estimations, the NEISS database is able to generate an injury cost model. This model is based on the age of the person, the severity of the injury, the amount of working time lost, and the amount of pain and suffering endured. From these data, NEISS provides an estimate of how much an injury will cost in lost revenue to a person and the amount of money required for treatment. It is from these estimates that our NEISS tables and charts were created.

This information is stored on a national database where it is released to cleared government agencies, who analyze the data to determine what products or activities are causing injuries, if the number of injuries is increasing or decreasing, and other information. These data allow an agency to determine which products or activities require their attention. One example of this is the CPSC's use of the NEISS databases to look into injury trends with ATVs.

The information gathered served a variety of purposes in support of our recommendations. For each activity the database research helped to determine the rate of injury.

It revealed which body parts were most likely to be injured, the type of injury suffered, the severity of the injury, and a cost model of the injury. In addition, the database also provided information on the age ranges of the injured participants, and what if any injuries are concentrated in certain age groups. All these data were extracted into Microsoft Excel, which was then used to generate charts to more easily comprehend our findings.

3.1.2 In-Depth Investigation

The In-Depth Investigation or IDI database is comprised of in-depth investigation reports that have been conducted by the CPSC staff. These reports are performed on products that the CPSC staff has deemed “hazardous” in order to develop a better understanding of the problems and possible ways the risks associated with use of the product can be mitigated. These reports offer additional information such as personal interviews with witnesses, police incident reports, background information on the product involved (occasionally mentioning its manufacturer), and some of the causal factors of the incident. This information allows the CPSC investigators to reconstruct the incident and analyze the major causal factors and how they could have been controlled or prevented.

This database gave a variety of data that were analyzed and categorized the same as the NEISS database. In addition to the information that correlated with the NEISS database, the IDI database incorporates death data, full incident reports, and what actions were taken to mitigate the problem. This database is used by the CPSC staff to analyze and test the mitigation strategies that are in effect, possible mitigation strategies that could work better, and the design of the product to see if it could be improved to make it safer. From the additional data supplied by the IDIs, such as complete incident reports and mitigation strategies that had been employed, our group was able compare mitigation strategies and their effectiveness.

3.1.3 Classification

To properly compare the given databases, it was necessary to create a classification model. This model would bridge the gaps in the data from database to database that is caused by the coding. The coding in the NEISS databases system is set up the same for all of their hospitals so that they can be easily compiled. However, when attempting to compare the NEISS and IDI databases, the coding system that is used is different and can result in inconsistent information. For example, the NEISS database breaks down the body into 31 different parts, but

the IDI database is broken down into only 27 body parts. In order to make these databases comparable, our group compiled these codes and grouped them into categories so that there was an equivalent sample from the databases.

3.2 Behaviors and Attitudes of Participants

The various databases did not contain information regarding participant behaviors and attitudes that could influence injury and death rates. To obtain this information, our group conducted a number of interviews with participants, participant and trade group organizations, and risk theorists who are familiar with our chosen HARAs. The goal of these interviews was to develop an understanding of what risks are involved with a specific activity, what is being done to mitigate them, what could be done, and what effective ways to market these mitigation and safety strategies to ensure compliance.

3.2.1 Participants

The purpose of these interviews was to provide the perspectives of participants who had first-hand experience in our chosen high adventure recreational activities, including trainers, professionals, and individual participants. Our group conducted internet research and spoke with our liaisons at the CPSC to develop a list of participant groups to interview.

Through these interviews, our group was able to make connections between the statistical data which was found in the databases and the human characteristics that influence the participants. These interviews gave insight into how the participants view the risks involved with their activity and others, why they do or do not practice certain safety measures, and what other ways they think the risks involved could be dealt with. Our group was then able to look at the behavioral traits of the participants and compare them with the injury and fatality trends that were illustrated by the statistical data.

3.2.2 Participant Organizations

These organizations are groups of participants that formally join together for a common goal. Participant organizations give small groups a voice and a forum to discuss their opinions. Through internet research, our advisors, and our sponsors at the CPSC, our group was able to contact and interview representatives from three ATV organizations and two organizations for each of the other three activities. The participant organizations interviewed were: the Vermont

ATV Sports Association (VASA), the All-Terrain Vehicle Association (ATVA), the Fox Valley All-Terrain Vehicle Association (FVATVA), the North West Ski Safety Council (NWSSC), the Los Angeles Council (LAC), the Southern California Mountaineers Association (SCMA), the American Mountain Guide Association (AMGA), the National Association of Underwater Instructors (NAUI), and the Ohio Council of Skin and SCUBA Divers Inc. (OCSSDI),.

The goal of these interviews was to develop an understanding of what representatives from each organization thought the risks involved with the activity were, the participants' views on safety equipment and training, and their opinions of the effectiveness of current risk mitigation strategies. This information allowed our group to develop an understanding of the organization's focus, what the representatives thought the general participants' attitudes were towards risk, and what mitigation strategies their group was promoting to protect their members.

3.2.3 Risk Theorist

Risk theory has many different aspects including risk perception, risk management, and risk marketing. Through talking with our liaisons, our group was able to contact and interview a member of the Human Factors division at the CPSC. The goal of this interview was to develop an understanding of risk theory, how it affects a person's interaction with a product, and how this could be marketed better. This information allowed our group to look at current risk management and marketing strategies and analyze their effectiveness. Once this analysis was conducted, our group was able to develop our recommendations about how these strategies could be improved or what strategies would work better.

3.2.4 Interview Structure

Our interviews were conducted in a semi-structured format by our entire team. This format enabled us to develop a set of prepared questions, but allowed enough flexibility to go into more depth where necessary. In order to allow enough time for in depth responses, our group performed one hour maximum interviews. The interviews were conducted in person whenever possible. Distance made it necessary to conduct some interviews over the phone. Due to the lack of time, our group used purposive sampling. This means that we interviewed key staff members within the CPSC who were able to direct us to others who would give us the information needed. Our group interviewed certain staff members at the CPSC more than once, as the research developed.

3.2.5 Surveys

During our research, it was shown that there was not enough time to conduct interviews of a representative sample of participants in our chosen HARAs. To resolve this issue, our group created and distributed surveys for our four chosen activities. These surveys were developed to give information about the behavioral aspects of the activities that could not be learned from the databases. These aspects include risk perception, acceptance, and management. The participants were then asked a series of questions comparing their activity to the other chosen activities and if they had ever participated in them. The reason for this is to develop an understanding of why people view other activities as more risky than those in which they participate and if they develop those reasons from fact, experience, or from rumor, media, bad images, etc.

These surveys were distributed to seven participant groups. To allow the groups easy access to our survey, our group used an internet website called SurveyMonkey.com© (survey monkey, 2007). This service allowed our group to build surveys, shown in Appendix D sections 8.4.2 to 8.4.5, and develop a link to place in an email or on a website for simple and rapid distribution. Once a survey was completed by a participant, the data were then categorized, analyzed, and graphed using the same program. These graphs were then used by our group for comparison with data given from the databases mentioned before.

3.3 Voluntary Standards

Some activities have requirements established by the CPSC's voluntary standards, including equipment design and performance. To gain a better understanding of these voluntary standards, our group interviewed a CPSC compliance officer and a CPSC voluntary standards coordinator. In addition, our group looked for voluntary standards that are in effect through the American Society for Testing and Materials (ASTM), the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO) to see how HARAs have been regulated. The interview minutes are available in Appendix E.

3.4 Analysis of Injury and Behavioral Data

The information generated by the research gave a great deal of insight into the problems involved with the chosen HARAs. Through the process of analyzing the data given from these various sources, possible trends and patterns were discerned within the HARAs. The data were helpful in determining what possible risk mitigation strategies are effective in one activity that could be used in another. The information given by the surveys illustrated the behavioral aspects of those who participate in these activities. This information was then compared to the NEISS and IDI database data to see if possible trends, which were illustrated by the database data, could be explained by the behavioral aspects of the participants within the activity. After a thorough review it was possible to develop recommendations to be used by the CPSC staff to better understand and investigate the problems with these activities.

3.5 Timeline

Project Goals	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	
	S M T W Th F S S M T W Th F S S M T W Th F S S M T W Th								
Sponsor Intro					Thanksgiving				
Initial Research					Thanksgiving				
Interviews									
Literature Review					Thanksgiving				
Assemble Data					Thanksgiving				
Drafting					Thanksgiving				
Final Research					Thanksgiving				
Final Drafting					Thanksgiving				
Presentation Prep					Thanksgiving				
Present Findings					Thanksgiving				
	S M T W Th F S S M T W Th F S S M T W Th F S S M T W Th								
	21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13								
	October				November				December

Table 3: D.C. Timeline

4 Findings

For each high adventure recreational activity (HARA) that was investigated, this section presents information derived from participant organizations, CPSC databases, surveys, and research into voluntary standards. This information is then summarized in an analysis at the end of each section.

4.1 All-Terrain Vehicles

This section contains the results and analysis of the data given for ATVs by the five sources that were researched. These sources gave a great deal of information such as; injury and fatality trends illustrated by the statistical data, the goals and mitigation strategies that are used by the participant organizations to decrease the risks involved in ATV riding, as well as the participants views on the amount of risk in their activity and how these risks should be mitigated. After compiling the data, comparisons were made in an attempt to link the statistical data, including the limited data on causal factors, to the behavior of ATV riders. Through this comparison, it was possible to develop possible mitigation strategies to reduce the number of injuries.

4.1.1 Participant Organizations: ATV

Representatives from three ATV participant organizations were contacted, including national, regional, and local organizations. A trade group was also contacted. The groups included were:

- The All-Terrain Vehicle Association (ATVA), a division of the American Motorcyclist Association (AMA), is a national association composed of over 9000 members spread amongst nine clubs located in separate states. The ATVA sponsors recreational riding and competitions (competition riding has an age restriction).
- The Vermont ATV Sports Association (VASA) is a regional association, located in Vermont, composed of about 1900 members from amongst 18 local clubs. Outside of ATV riding, VASA has trail organizations and fundraisers.
- The Fox Valley All-Terrain Vehicle Association (FVATVA) is a small association in Wisconsin currently composed of only ten people, but they have had up to 60 people in the

past. The FVATVA holds one meeting a year due to their small size. No other information was gathered about their organization aside from the advertised riding sessions on their website.

- The ATV Safety Institute (ASI) is a division of the SVIA. Thirteen different ATV manufacturers are members of the ASI.

A common theme in these organizations' mission statements is the provision of trail access through lobbying for regulation of land use, public awareness, and trail maintenance. The ASI feels that legislation is necessary to enhance rider safety, and continues to promote the SVIA's model state legislation that addresses age limits and other ATV operation restrictions. These organizations have commented about what should be done to promote responsible regulation to protect riders.

All three ATV organization representatives mentioned that a lack of experience is a leading cause of injuries related to ATVs. The ATVA representative added that most manufacturers provide free training with the purchase of an ATV. In addition, dealers are making consumers aware of free training by requiring a person to sign a contract acknowledging that there is a training program available and offering an incentive (\$100 rebate/bonus) for taking the training course. Although none of the ATV organizations sponsor their own training program, their spokespersons commented that proper equipment use and responsible driving can help prevent injuries. In addition to advocating appropriate education, the ATVA representative strongly emphasized proper supervision over inexperienced riders, such as children; because ATVs require a key to use, a parent should always have control over when a child uses an ATV.

All of the organizations strongly encourage ATV riders to get training. Training provides details about how to drive responsibly and how to prevent an injurious incident from occurring. The ATVA representative recommended the ATV RiderCourse run by the ASI which, according to the ASI representative, has helped train over 750,000 riders since 1989. The ATV RiderCourse is available to children at least six years old, but a parent must supervise any child less than 11 years of age. In addition, any child less than 16 years old must ride a youth ATV model. The ASI gives a small description of what their RiderCourse training program offers:

Students practice basic safety techniques with hands-on exercises; such as starting and stopping, turning (both gradual and quick), negotiating hills, emergency stopping and swerving, and riding over obstacles. Particular emphasis is placed on the safety implications relating to each lesson. The course also covers

protective gear, environmental concerns and local laws. Participants receive the ATV RiderCourse Handbook, which reinforces the safety information and riding techniques covered during the ATV RiderCourse. (ASI, 2007)

Although the three organizations do not run training programs, each organization takes a different approach to address the issue of safety. ATVA publishes and distributes articles within the organization. These articles, entitled “Safety First”, present case studies of ATV riders who have been seriously hurt or killed in an ATV-related incident and analyze the riders’ mistakes. In addition, the ATVA representative suggested educational programs in grade school on safety; while there are bicycle safety campaigns, there are no youth ATV safety campaigns. To alert ATV members on safe riding, VASA has a Code of Ethics, published in their newsletters, that outlines safety and proper behavior while riding an ATV. The FVATVA representative could not comment on addressing safety, but did mention that that FVATVA rarely has injuries reported within the organization (no injuries in three years).

The ASI has taken a number of actions to promote public safety awareness and education. Among these are the promotion of 21 public service announcements, which advocate age and size recommendations, parental supervision, environmental responsibility, training, protective gear, and not carrying passengers. The ASI has also distributed booklets on proper use of an ATV and how to determine when a child is ready to ride an ATV, a video on the elements of safety when riding an ATV, and an interactive CD-ROM for children. The video has been viewed by almost 4 million people, and the CD-ROM has been distributed to 1.7 million children. The ASI also has a hotline service dedicated to providing safety and training information.

4.1.2 Injury Data: ATV

In researching the databases provided by the CPSC, a large amount of data was obtained regarding ATV-related injuries. This raw data was filtered to give the exact number of reports that the National Electronic Injury Surveillance System (NEISS) had acquired over the past seven years. The number of reports given by this database was then put into a formula, contained within NEISS, to develop an estimated number of injuries related to the activity, as shown in *Figure 17* (NEISS, 2007). Every injury report that is entered is assigned a weight, which was used by NEISS to calculate the estimate. However, this NEISS estimation is also assigned a coefficient of variance which accounts for the variability in the data. This coefficient

when applied to *Equation 1*, will give the high and low values of the NEISS estimate with a 95 percent confidence interval. *Figure 17* illustrates that according to the estimate generated by the NEISS database, there is an increasing trend in the number of injuries. The variance in the NEISS estimates is illustrated in *Figure 17* by the error bars on each point.

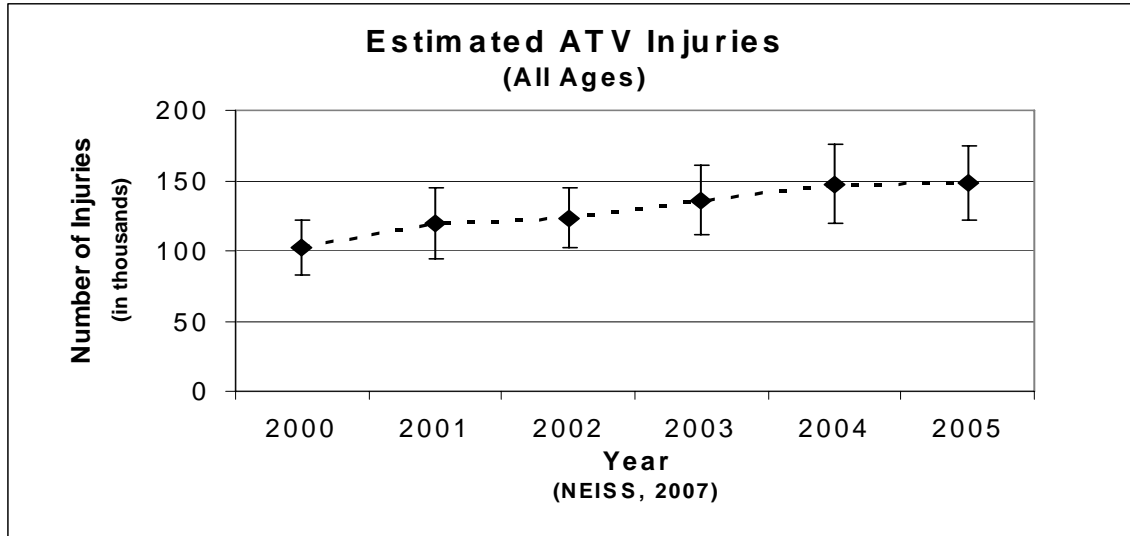


Figure 17: Estimated ATV Injuries

In *Figure 18*, the numbers of injuries estimated by NEISS, were converted into a rate of injury per ATV in use in millions (CPSC, 2005), which is represented by the solid red line. The dotted black line represents the estimated number of injuries supplied by NEISS that occurred over this seven year period (NEISS, 2007). Although this graph illustrates a decreasing trend in the rate of injury, it cannot be confirmed due to the variance of the injury estimates given by NEISS.

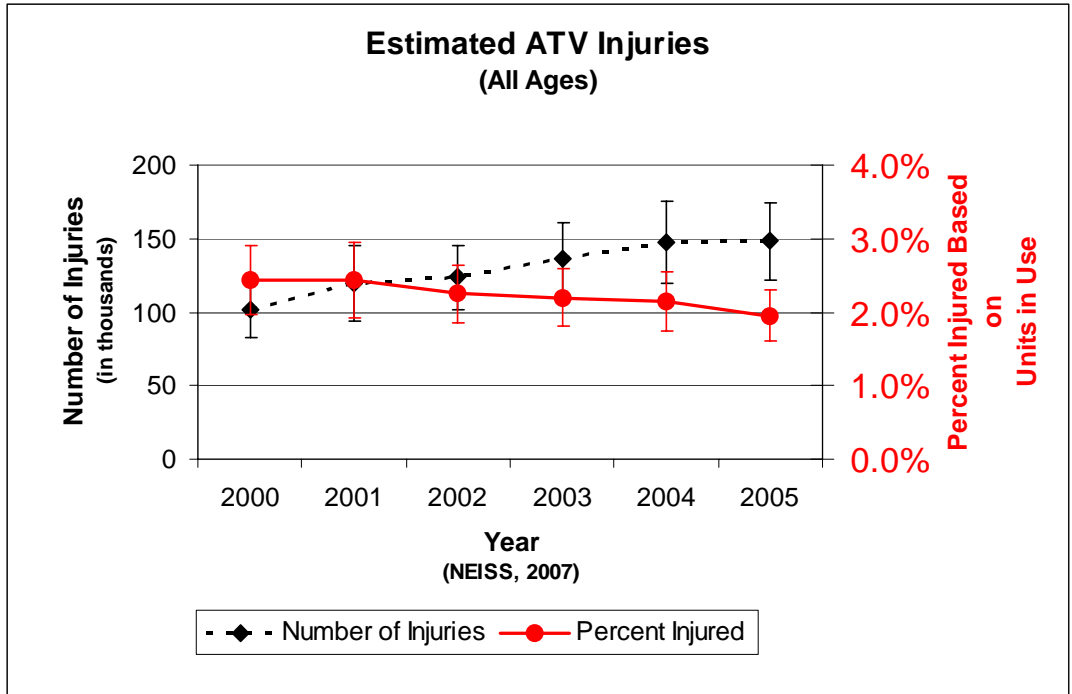


Figure 18: Injury Rate vs. ATVs in use

Figure 19 illustrates the disproportional distributions of injuries between the age groups and genders. For example, ATV riders age 15-19 made up almost 20 percent of the estimated number of injuries from 2000 to 2006 given by NEISS. During that same time period, males accounted for three quarters of the injuries. From these data, a hypothesis was formed that men are more likely to be injured than women while riding an ATV. However, due to a lack of participation data, this hypothesis is unable to be evaluated.

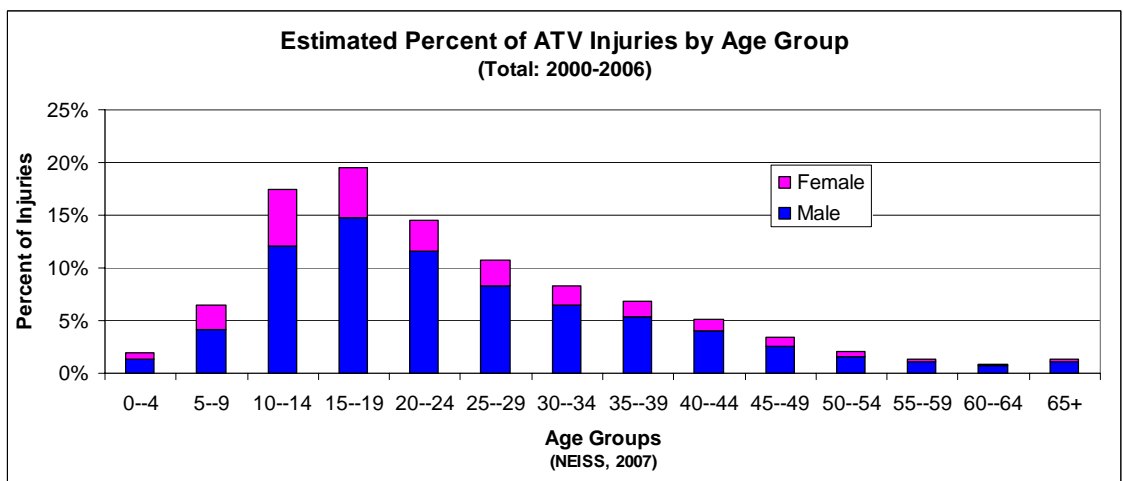


Figure 19: Estimated Percent of ATV Injuries by Age Group

While looking into the injury data another question arose which was, what are the most common types of injuries that occur in ATV riding? By filtering the database, the top five injury types for ATV riders were obtained. These data were then converted into percentages of the total number of injuries. As shown in *Figure 20*, the largest two injury types are contusions/abrasions and fractures. Although contusions and abrasions make up a larger percentage of the total number of injuries estimated by NEISS, over 25%, the level of treatment required for a fracture is much greater; roughly 25 percent require hospitalization.

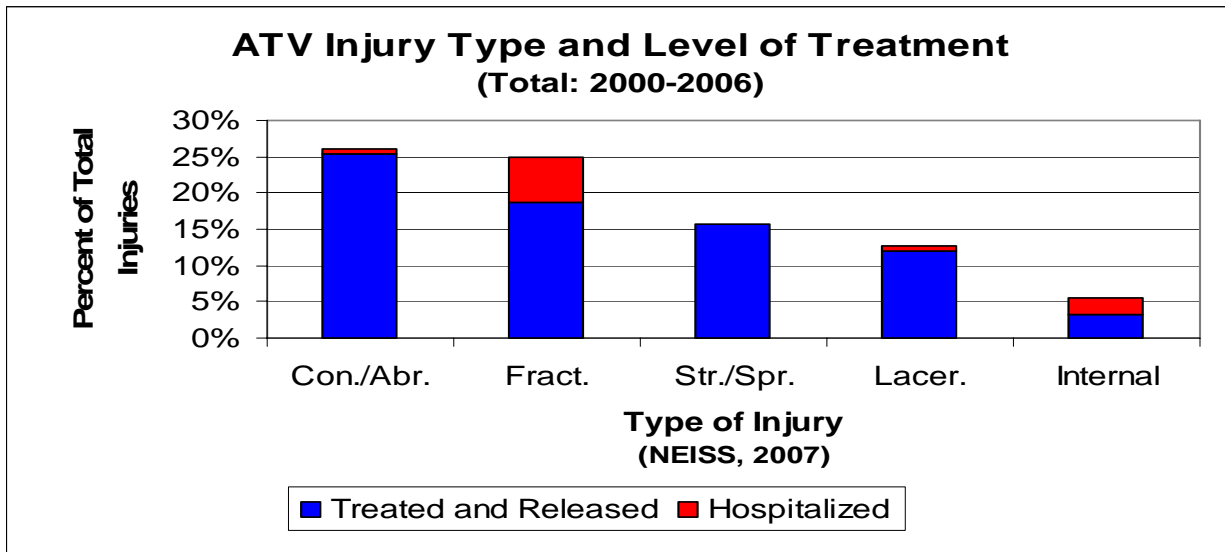


Figure 20: ATV Injury Type and Level of Treatment

Filtering the database showed what body part was most often injured and what percentage of the total number of injuries those injuries represented, as shown in *Figure 21*. These data were also broken down by the level of treatment that was necessary, represented in *Figure 20* by the red blocks. For example, head injuries represent not only the highest percentage of injuries, but also those that most frequently require hospitalization.

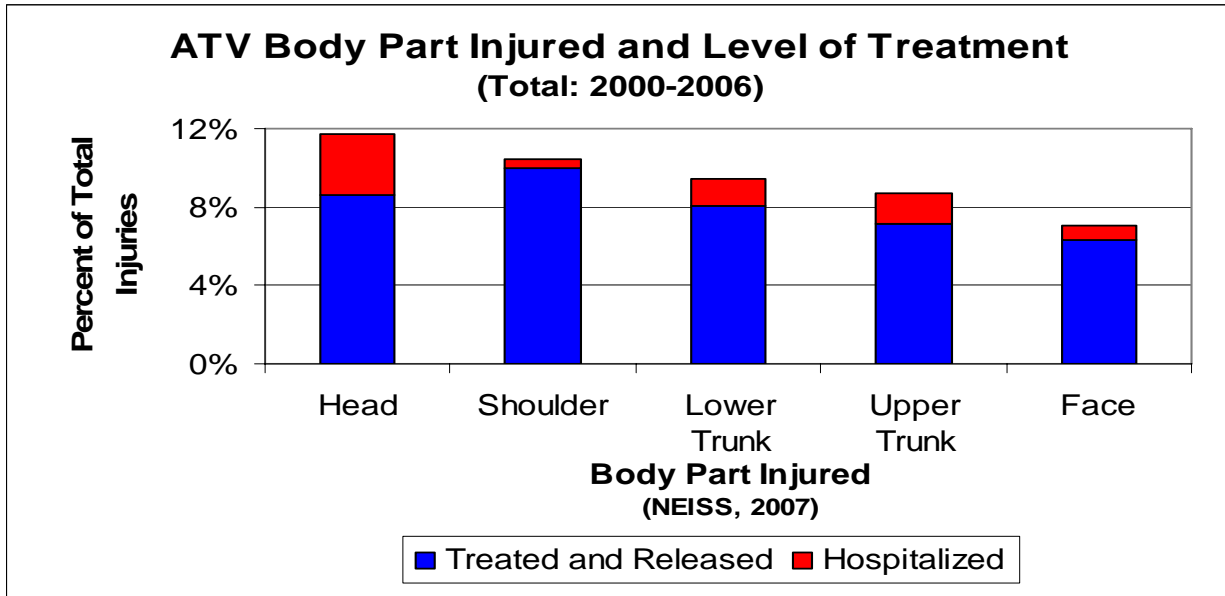


Figure 21: ATV Body Part Injured and Level of Treatment

The NEISS data was then analyzed to determine which body part is affected most by a specific injury type. This graph does not however, represent the total number of injuries estimated by NEISS. When looking at *Figure 22*, it can be noticed that not all of the bars reach 100 percent and when adding the five bars together, the value exceeds 100 percent. The reason for this is that the top five body parts only make up a percentage of each injury type and do not represent the total number of injuries of that type for the entire year. *Figure 22* shows what percentage of the top five types of injuries that occur to the top five body parts shown in *Figure 21*. For example, *Figure 22* illustrates that head injuries made up over 90 percent of all internal injuries. However, when looking at contusions/abrasions, it is shown that the top five body parts injured make up only 50 percent of the total number of contusions and abrasions related to ATVs.

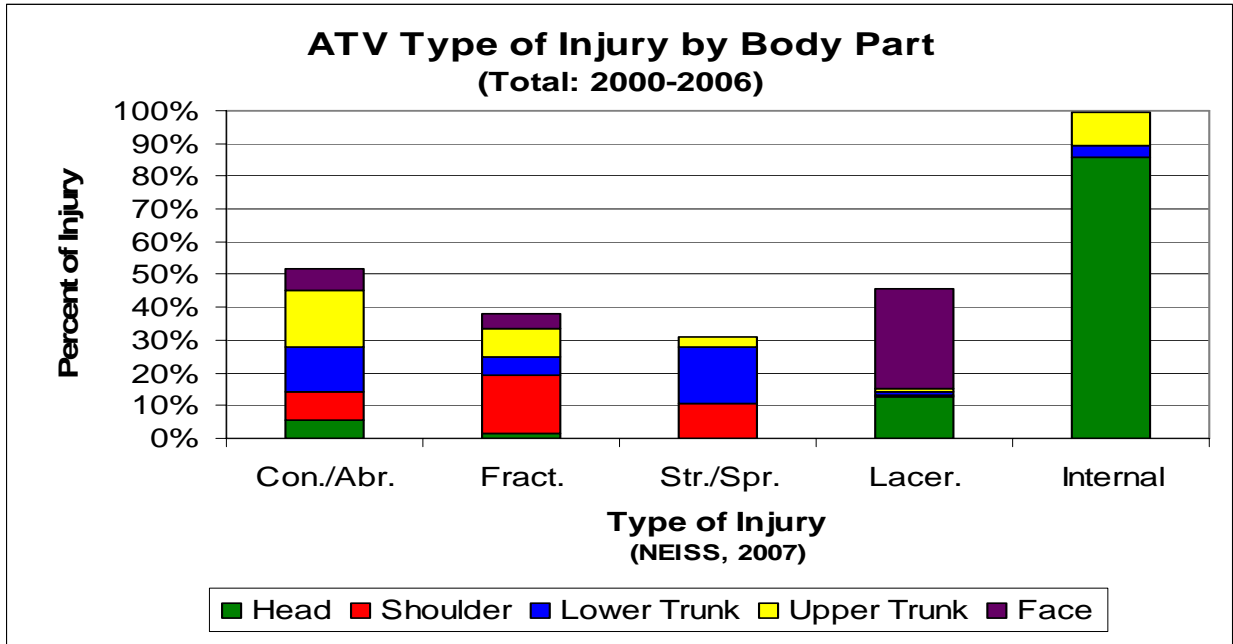


Figure 22: ATV Type of Injury by Body Part

To investigate if the age of a participant had an effect on the location of an injury, the NEISS database was filtered using the most common five body parts injured and then by age group, as shown in *Figures H-1 to H-3* (Appendix H: Supplementary Data). The age groups that were used were 0-4, 5-14, 15-24, 25-64, and 65+. Due to the relatively small sample sizes and inaccurate estimates in the 0-4 and 65+ age groups, these graphs were not included. One commonality that is shown in *Figures H-1 to H-3*, is the head injuries. Head injuries make up roughly 10 percent of the total number of injuries annually for these groups. When looking at the age groups separately, it is shown that although head injuries represent the highest percentage, the second highest percentage varies between ages. For example in the 5-14 year old age group, facial injuries make up almost the same percentage as head injuries, but for the 15-24 year old range shoulders are the second highest. One possible explanation for this could be the different types of riding that are practiced. In the 5-14 year old age range participants are most likely learning the basics of the activity, but in the 15-24 year old group participants are possibly more experienced and attempt more risk maneuvers. However, this hypothesis cannot be proven due to a lack of causal data.

Another part of our research included attempting to discern a possible correlation between the age of a participant and the type of injury they suffered. The data shown in *Figures H-4 to H-6* (Appendix H: Supplementary Data), were divided into the same age groups as

Figures H-4 to H-6 for easier comparison. One trend that can be noticed through a comparison of the graphs below is that contusions/abrasions and fractures make up almost 50 percent of the injuries that occur in all age groups, while the other three combined make up only about 20 percent. When looking at the other age groups it can be noticed that the distribution of strains/sprains, lacerations, and internal organ injuries remains relatively the same from year to year and between the age groups. This suggests that although the body part injured differs, as noticed in *Figures H-1 to H-3*, the type of injuries that are sustained remains almost uniform between the age groups. However, due to the variance involved with the NEISS estimates, it is impossible to draw any concrete conclusions.

4.1.3 IDI Results: ATV

Numerous In-Depth Investigations (IDIs) conducted by the CPSC staff have revealed that many incidents have similar characteristics. According to our analysis of the many IDIs from 2000 to 2006, as well as the ASI's study of the IDIs from 1997 to 2002 as mentioned in their interview (ASI, 2007), participants were injured or killed due to at least one of the following reasons: not wearing a helmet; carrying at least one passenger on an ATV; a child riding an adult sized ATV; riding on a public road; and alcohol or drugs. While information on level of training was unavailable in the fatality-recorded IDIs, our group sampled 10% of the 541 injury-recorded IDIs to determine the level of training received by the rider. Out of 53 IDIs, none of the injured riders received formal training from a safety instructor. A majority of the injured participants either received training through a friend or relative or did not receive any training at all. In addition, only one person received training through a video.

4.1.4 Participant Surveys: ATV

Through the distribution and collection of surveys, a great deal of information was learned about the behavior of ATV riders. The two topics that were investigated by this survey were: the amount and type of training participants thought was necessary and their views towards safety equipment. These two factors were important because they show the participants' attitudes towards the risk involved with the activity and how they deal with these risks.

This survey was distributed through SurveyMonkey.com© (surveymonkey, 2007) to two participant groups. These groups were the Annapolis/Baltimore meet-up and the Camp Reno Hunting Lodge. Of the almost 60 participants that the surveys were distributed to, there were

only six respondents, giving only a 10 percent response rate. Even though this is a very small sample size, this was still a valuable tool for understanding some of the behavioral aspects of the activity.

Of the people who took this survey, ranging in age from 12 to 48, not one person had ever taken a safety or training course. When asked later how a child should learn how to ride an ATV, the majority of respondents stated that children should learn from an experienced driver, not necessarily an instructor. This shows that participants believe that an experienced person, whether the experienced driver has taken a training course or not, will be able to properly teach a child all that the child needs to know. However, this informal training could leave out important information needed to keep a participant safe. One example of a message that is not getting across through informal training is to not carry a passenger on a single person ATV. Almost two-thirds of the participants still carry passengers, regardless of warning labels.

Survey responses indicate that participants are likely to use safety equipment. The majority of participants wore more than just a helmet for protection. For example, more than three-quarters of those surveyed wore a helmet, gloves, and goggles and two-thirds wore boots when riding. This is interesting because the participants, who, as mentioned before, have never attended any training courses, feel that extensive safety equipment is necessary. This information indicates one of two participant attitudes. The first possible explanation for this is that training courses are inaccessible to activity participants or not well advertised to people purchasing ATVs. The second is that people are unwilling to take a training course because they do not feel the courses are necessary to learn how to properly operate an ATV.

The respondents were also asked to rate, based on their perception, which of the chosen activities involved the highest, high, moderate, and lowest amount of risk. The options were skiing, SCUBA diving, rock climbing, and ATV riding. Of the respondents, about two-thirds stated that rock climbing had the highest risk, about half stated that skiing and ATV riding had moderate levels of risk, and about one-half stated that SCUBA diving had the lowest level of risk.

4.1.5 Voluntary Standards: ATV

Over the past few decades, voluntary standards have been developed to establish "...minimum requirements for four wheel all-terrain vehicles effective for models produced after the date that this standard is approved..." (SVIA, 2007). The most notable of these is the

American National Standard for Four Wheel All-Terrain Vehicles. This standard was initiated in 1985 by the Specialty Vehicle Institute of America (SVIA) and was completed and published as ANSI/SVIA 1-1990. This standard has been revised twice since its creation, once in 2001 and again in 2007. During these revisions many changes were made to the standard in order to stay up to date with current technologies that manufacturers are producing, to modify the language of definitions in case they have changed, and to add provisions to clarify the standard's requirements (SVIA, 2007). One example of a recent revision is the classification and definition of Type I and Type II ATVs, which was added in 2007. The following sections of the standard state the requirements for vehicle specifications:

Section 4: Vehicle (ATV) Equipment and Configuration;

Section 5: Maximum Speed Capability;

Section 6: Category Y and Category T Speed Capability Requirements;

Section 7: Service Brake Performance;

Section 8: Parking Brake/Mechanism Performance;

Section 9: Pitch Stability;

Section 10: Electromagnetic Compatibility;

Section 11: Sound Level Limits;

Section 12: Certification Labels (SVIA, 2007).

Each section is broken down into two parts: a description of the specifications for the mechanical components, and proper testing conditions and procedures for those components.

The mechanical breakdown is described in Section 6, which explains the standard for Category Y and T Speed Capability Requirements. These categories are defined in the early sections of the standard as youth and transitional ATVs that require speed limiting devices. This section specifies the maximum unrestricted speed for each age group, maximum limited speeds, the limiting devices and their adjustments. It also states that all machines must be delivered with the device adjusted to the lowest maximum speed. These mechanical factors are then tested by the manufacturers that follow the standards.

ANSI/SVIA 1-2007 clearly states the proper conditions and procedures for testing an ATV. The tests must be conducted under predefined conditions and with a replicable procedure so that all test results have only one variable, in this case, the machine.

Warning and information labels on ATVs are also covered by the ANSI/SVIA standards. These labels inform the rider of various safety information about the ATV and some of the risks that may be encountered while driving. For example, hangtags are placed on ATVs while they are still on the showroom floor and cannot be removed until the vehicle is sold. These tags give information such as the age restriction on the vehicle, what type of ATV it is, Type I or II, that a driver should never carry a passenger, and that training courses are available. These tags are intended to educate ATV buyers about risks and some ways in which risks can be reduced.

These standards were created to make ATV riding safer for participants. They provide a series of safeguards such as speed limiters for children, engine shut off switches in case of emergencies, and warning placards to constantly remind the participant of the risks involved. Through the rigorous testing that is involved, the manufacturers, as well as other organizations like the CPSC, are able to identify and resolve problems with the product before it can cause injuries. Note however, that this is a voluntary standard and is not adhered to by all manufacturers.

4.1.6 Analysis: ATV

Through an analysis of the data presented above, it was possible to make correlations between the injury data given by the databases, the survey responses, information obtained from the participant organizations, and the voluntary standards that are used to regulate the industry. These correlations allowed our group to better understand the data and patterns shown by the variety of sources.

The participant organization interviews show that the education of their members through certified training courses was a common goal. Furthermore, voluntary standards require the dealers to include hangtags on new ATVs that provide information about available training courses. However, surveys of ATV riders showed that none of the participants had ever taken a training course. This indicates that the participants are not receptive to formal training.

However, when asked about the use of safety gear, three-quarters of the survey respondents stated that they wore helmets and two-thirds wore additional safety equipment such as gloves, boots, and goggles. This could indicate that the marketing strategy that is being used to promote the safety equipment is highly effective and could be applied to training.

Another injury comparison that was made within the NEISS data is the number of head injuries that occur. As can be seen in *Figure 21*, head injuries are one of the most common

injuries in ATV riding and almost 25 percent of head injuries required hospitalization. Comparing *Figure 22* with *Figure 21*, it can be seen that head injuries make up almost 90 percent of the internal organ injuries and that when internal head injuries occur; roughly 30% are serious enough to require hospitalization. This gives a possible rationale as to why half of all ATV-related internal organ injuries, shown in *Figure 20*, require hospitalization. One possible factor that could contribute to the number of severe head injuries is a lack of helmet use. Even though three-quarters of survey respondents claim to wear helmets while riding; this hypothesis was supported by the information given by the IDI database, which showed that lack of helmet use was a possible factor in a number of ATV-related injuries and fatalities.

An analysis was also conducted to see if the current voluntary standards were effective. Due to the fact that participation rates are unknown and the estimates generated by the NEISS database had such a large variance, it was not possible to determine the standards' effectiveness.

4.2 Skiing

The results of the skiing investigation provide some insight into the types of risk skiers are exposed to and the level of concern skiers have for safety. The investigation was conducted in the same manner as it was for the other three HARAs; with interviews of skiing organization leaders, NEISS database estimates, IDI database reports, and skier surveys.

4.2.1 Participant Organizations: Skiing

Representatives from two skiing participant organizations were contacted. Both were regional groups, a small division of the Far West Ski Association (FWSA):

- The Los Angeles Council (LAC) is comprised of 30 ski and snowboard clubs. Outside of skiing, the LAC has summer volleyball, a "Ski Week", a Man/Woman of the Year contest, and trips to places like Costa Rica.
- The North West Ski Club Council (NWSCC) is an association of 35 clubs with about 10,000 members. The NWSCC holds a variety of activities all year, including hiking, biking, golfing, and picnics.

The FWSA's mission is to "develop and provide benefits for all affiliated clubs and members" (FWSA, 2007). While the LAC's mission statement was not available on their website, the NWSCC expands on the FWSA mission statement, to "provide input with government entities regarding decisions that will ultimately affect skiers and snowboarders with

regards to the roads we travel, the mountains we ski and board on, the resorts we visit, and the rules we use to share both effectively, with the non-skiing and non-snowboarding public” (NWSCC, 2007).

There were only a few reasons cited by both representatives as to the causes of injuries. The LAC representative commented that injuries occur when skiers take off on a ramp, which can lead to head and back injuries. The LAC representative further mentioned that people can get knee injuries from short skis. She also said that snowboarders are a contributing factor to injuries because they do not pay attention to their surroundings. The NWSCC representative mentioned that there is always inherent risk involved in skiing, such as skiing out of control, but did not provide the specific reasons for skiing out of control.

Like the ATV organizations, both skiing organizations stress safety with great concern. The LAC representative mentioned that the LAC holds meetings to discuss trip insurance programs and also displays new equipment like helmets. The LAC also sells helmets, and other equipment and services, to skiers at a discount. She added that 80% of Mammoth Hill (a ski resort visited by members of the LAC) skiers wear helmets, and that helmets have helped to reduce the number of head injuries to skiers. The LAC representative added that a skier should always wear proper equipment, be properly educated, not ski beyond their ability or be persuaded by peer pressure, and be physically fit, in addition to dressing warmly. The NWSCC has developed presentations addressing the issue of safety and has distributed several articles discussing methods of keeping safe. In addition, the FWSA promotes annual safety contests within the NWSCC; any members that promote safety, either by volunteering for the ski patrol, participating in a community to raise safety awareness, or simply exercising safe skiing skills, can win a trip to Aspen. The NWSCC feels that injuries can be further reduced through campaigns for safety awareness.

4.2.2 Injury Data: Skiing

There has been a decrease in the estimated number of skiing injuries over the past several years. Between 2000 and 2003 the estimated number of injuries decreased by about half. The decrease could be explained by a change in the number of people skiing. *Figure 23* displays the NSAA estimates of people skiing and snowboarding. The number of people snowboarding is included because, if the ski slopes were becoming less crowded because of fewer people skiing, then that might be a possible explanation for increased slope safety. With the growing popularity

of snowboarding, it is evident that the number of persons on the slopes hasn't shifted from roughly 12 million each year. Another potential explanation could be that snowboarding has attracted younger, more injury prone participants, that would otherwise have become skiers.

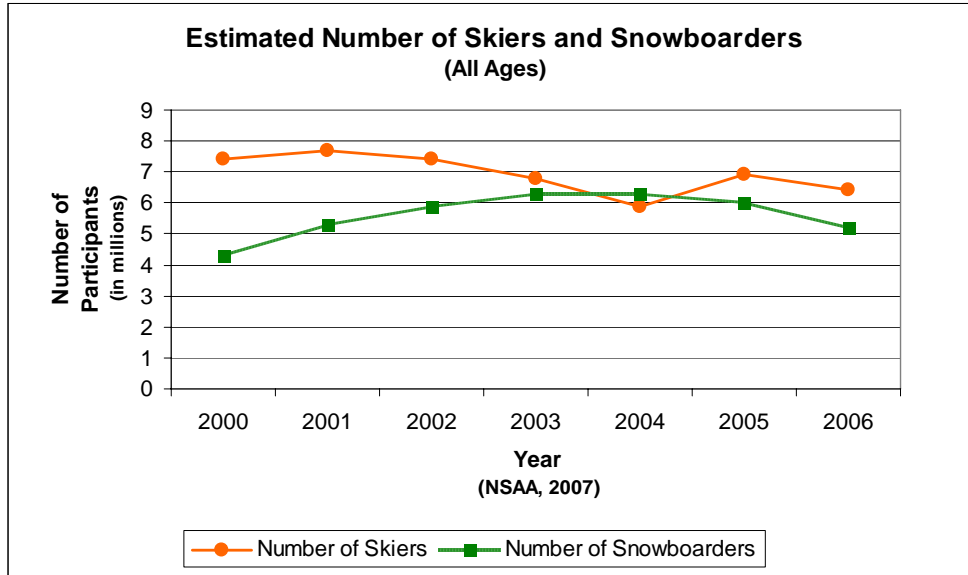


Figure 23: Estimated Number of Skiers and Snowboarders

According to the NEISS estimates, the number of people injured while skiing has decreased. When the error is included, as shown in *Figure 24*, it is impossible to make such a statement with any confidence. Even though the error is large, it is still the most accurate data available on skiing injuries. The percent of skiers injured was calculated using the estimated number of skiers to have visited U.S. resorts that year. It does not include snowboarders or other snow-sport participants; it was calculated using only the number of skiers from *Figure 23*.

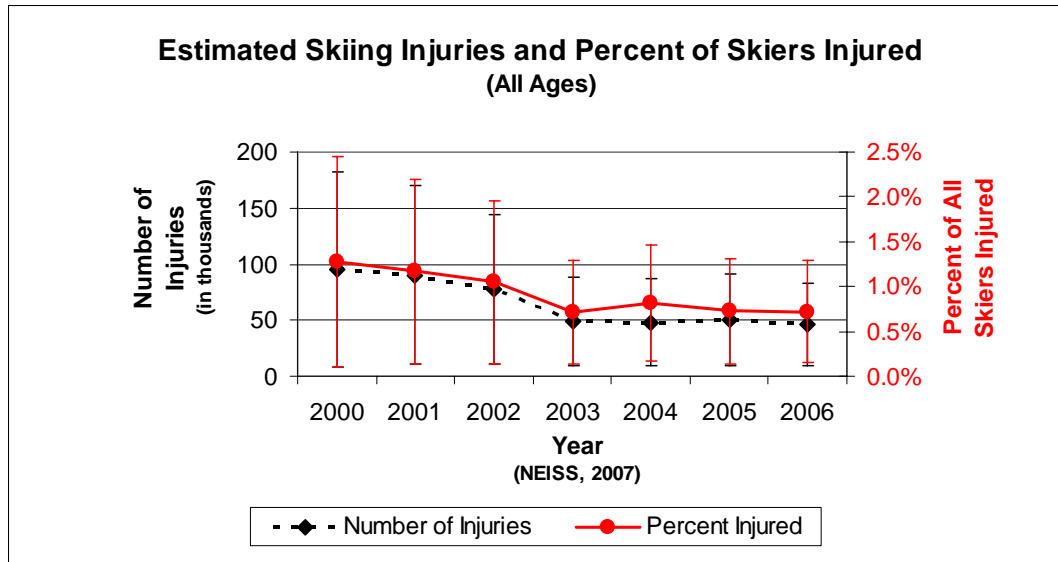


Figure 24: Estimated Ski Injuries and Percent of Skiers Injured

Ski injuries are not distributed equally among the age groups of the participants. About a third of those injured are estimated at 18 years old or less. Male injuries make a definite majority of the injuries, however injured females make a much a larger percentage compared to the other three HARAs in our investigation. The NEISS estimates, shown in *Figure 25*, illustrate a definite peak in injuries for skiers in their teen years and another, smaller peak for skiers in their early to mid forties. The NSAA reports that the number of visitors to ski resorts has been stable for the past 30 years; however, demographic data on the distribution of participant ages is not available (NSAA, 2007). This stability suggests that skiing is a family sport passed down from one generation to the next. Based on this model, it is possible that a person is able to ski when they are young because their parents pay for the costs. As they grow older and must pay for themselves, have less free time, and have young children to care for, the amount they ski decreases. Once they are well established with higher income jobs, and their children are older, they begin to ski again. This theory that our group developed could explain the peaks in the age distribution of injuries. In the absence of participant age distribution data, it is not possible to determine whether the high injury rate for teens is disproportional to the participation rates.

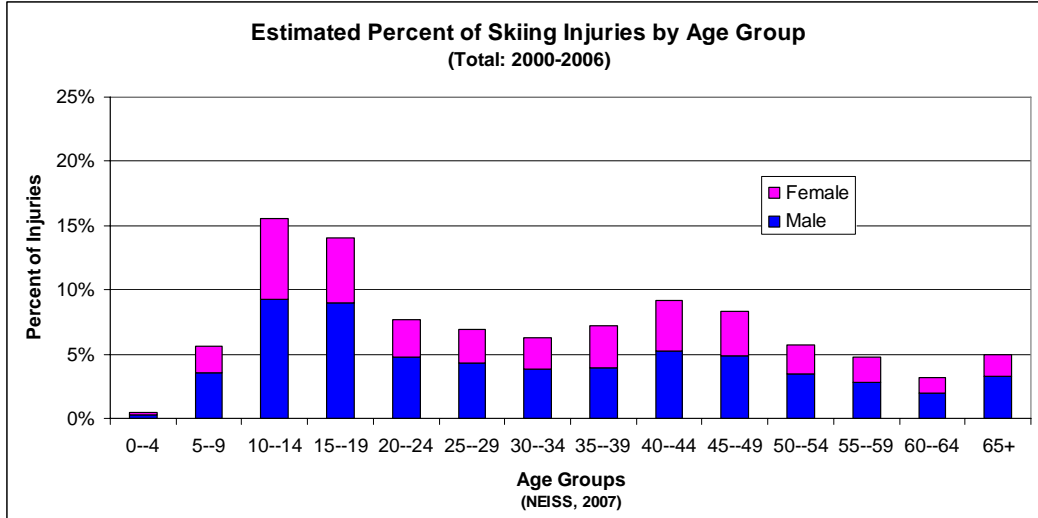


Figure 25: Estimated Percent of Skiing Injuries by Age Group

The most common injuries associated with skiing, as shown by the NEISS estimates in Figure 26, are strains and sprains, fractures, contusions and abrasions, lacerations, and dislocations. These five categories constitute over 80% of all skiing injuries. Strains and sprains are the most common at roughly a third of all ski injuries. Fractures make up a smaller percentage of the total number of injuries, but are the most serious of the five types of injury listed.

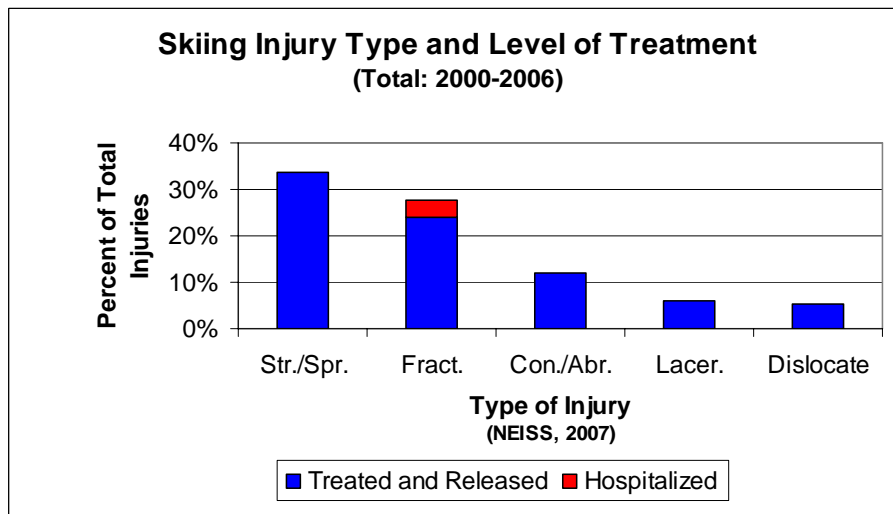


Figure 26: Skiing Injury Type and Level of Treatment

In addition to knowing what types of injuries are common to skiing, it is important to know where on the body the most injuries occur. The most commonly injured body parts associated with skiing are as shown by the NEISS estimates in Figure 27, in order from greatest

to least: the knee, the shoulder, the head, the lower leg, and the lower trunk, accounting for nearly 60% of all ski injuries. Knee and shoulder injuries are the more common locations of injury but are less severe than those that are less common. Head, lower leg, and lower trunk injuries all account for a significant percentage of the total number of injured skiers hospitalized.

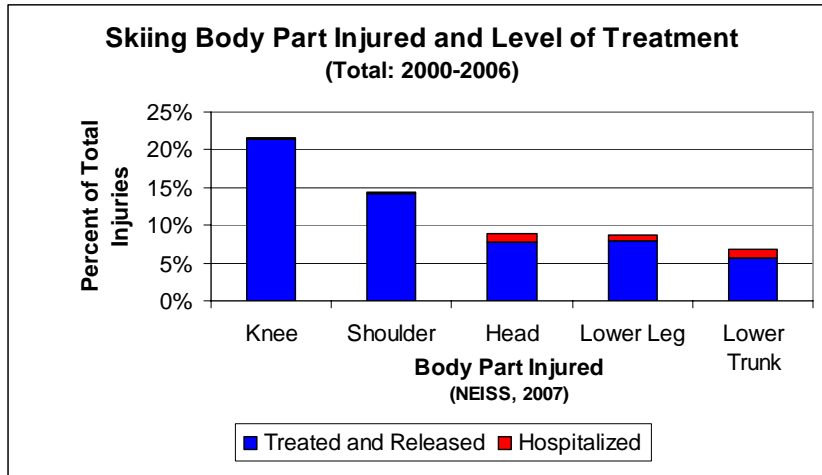


Figure 27: Skiing Body Part Injured and Level of Treatment

The next step in our research was to determine if the most common injuries were to the most commonly injured body parts. Figure 28 displays these NEISS estimates with some interesting results. About half of all strains and sprains affected the knees. Fractures were primarily located in the lower leg and shoulder. A majority of lacerations were to the head and an overwhelming percent of dislocations were of the shoulder. These data will be valuable when making recommendations about possible injury mitigation strategies.

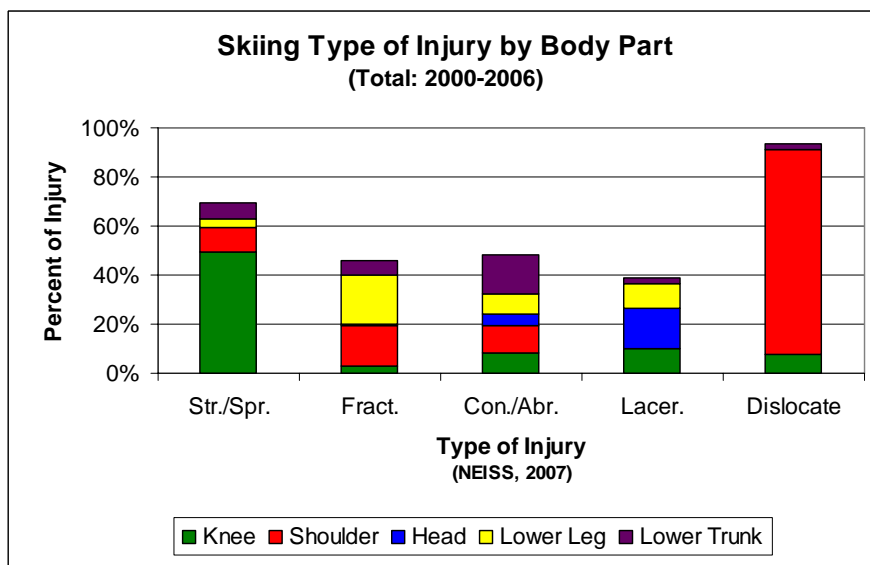


Figure 28: Skiing Type of Injury by Body Part

Part of our research included attempting to discern a possible correlation between the age of a participant and the injured body part or the type of injury they received. The participants were divided into five age groups; 0-4, 5-14, 15-24, 25-64, and 65+. The charts of this data can be seen in Appendix H as *Figures H-7 to H-12*. The 0-4 and 65+ age groups were not included because they make up a small number of the injuries and the estimates generated for them were not as accurate due a much smaller sample size. In each of the three age groups the trend for both the types of injury and the body parts injured has remained relatively constant. Knee injuries and strains and sprains were prevalent throughout, both averaging about 20% of all injuries each year. During this time, no new voluntary standards for skiing were created, only updates of previously existing standards. The NSAA had two safety awareness campaigns that were ongoing or started during this time period. This information is useful because the stability of the injury trends shows that, even though there were voluntary standards for the equipment and safety awareness campaigns for participants, neither made a significant impact on the number of estimated injuries received by skiers.

4.2.3 IDI Results: Skiing

There were only eight IDIs available in the CPSC database. These were used to analyze possible conditions that caused a person's incident. It should be noted that these conditions are not a definite cause of an incident; even if a person is wearing a helmet, it is possible that a strong enough impact to the head may cause a serious injury or even death. A majority of the eight IDIs involved the skier colliding with a stationary object, such as a rock or tree. This is common because ski trails often run through dense forests or rocky slopes. Other possible hazards that line ski trails include snowmaking machinery and the pipes that carry the water and air up the mountain to the snowmaking machinery. The most common occurrence of injuries was from skiers who lost control. It is possible that their loss of control was caused from excessive speeds or faulty equipment. The next most common possible condition contributing to the incidents was eight reports of the skier not wearing a helmet during the accident. In all eight cases, the skier hit their head on a tree or rock and died. Other causes of an incident were due to a skier's inadequate skill. There were four cases that a skier's ability was not on par with the course he or she was skiing on.

4.2.4 Participant Surveys: Skiing

Through the distribution and collection of surveys, a great deal of information was learned about the attitudes and behaviors of skiers. The surveys investigated two topics, the amount and type training participants thought was necessary and their views on safety equipment. These two factors were important because they show the participants' attitude towards the risk involved with the activity and how those risks are dealt with.

To obtain a representative sample of participants the survey was distributed to two participants groups, which were the Ski Liberty Patrollers and the Cornell Outdoor Education program. Out of the roughly 150 participants that were given the survey, only 22 participants responded. Due to the small sample size, no absolute conclusions may be drawn from this data. However, from this data possible links between the behaviors of the participants and the number of injuries can be analyzed.

The surveys showed that participants believe that skiing presents a high level of risk. This is one possible explanation why training is stressed in skiing. When asked how a child should learn to ski, the majority of participants stated that a child should learn from a certified instructor. The participants were also asked how they learned to ski to see if they wanted their children to learn the same way that they did. Of the participants, two-thirds stated that they had learned from instructors. This trend shows that the respondents who have taken a training course believe that it is an effective way to develop the skills necessary to ski safely.

One mitigation strategy not taught by training schools is the use of helmets. When asking about the use of helmets in skiing, it was found that less than one-third of the respondents wore a helmet. One rationale that was expressed in the survey is that helmets are unnecessary unless performing aerials, which are stunts requiring the skier to go airborne off of a jump.

The respondents were also asked to rate their perception of the level of risk involved with ATV riding, SCUBA diving, rock climbing, and skiing; from highest to lowest. Of the respondents, more than half stated that ATV riding had the highest level of risk; about one third stated that skiing and rock climbing had high levels of risk, and about half stated that SCUBA diving had the lowest level of risk.

4.2.5 Voluntary Standards: Skiing

There are over 30 active voluntary standards that regulate skiing equipment. These standards are created by the International Organization for Standardization (ISO) and are adopted by the American National Standards Institute (ANSI) (ISO, 2007). They have also been created by the American Society for Testing and Materials International (ASTM). Nearly all of the standards involve the creation of methods for testing ski equipment and how to measure the results, such as ISO 6003:1984, *Alpine skis—Determination of Mass and Polar Moment of Inertia—Laboratory Measurement Method* (ISO, 2007). About half of the active standards are the most recent update of a standard originally created in the early 1980s.

The majority of the standards focus on the skis, ski boots, and the bindings that attach the boots to the skis. ISO 11088:2006 includes all three, detailing the: Assembly, Adjustment, and Inspection of an Alpine ski/binding/boot (S-B-B) System (ISO, 2007). They comprise the majority of the standards because they are what make skiing possible. A skier needs to have skis and bindings that can be securely attached to each other and be properly aligned and centered. The bindings must be able to hold the skier to the skis, and be set to release only when necessary. Ski boot standards are required to enable one manufacturer's brand boot to fit another manufacturer's brand binding.

There is a standard for snow-sport helmets, meaning they can be used for skiers or snowboarders: ASTM F2040-06 Standard Specification for Helmets used for Recreational Snow-sports. It requires the helmet to withstand a 22.5 km/h (14 mph) impact similar to the bicycle helmet standard, except that it has a greater temperature range (low: -22° to -28°C, high: 32° to 38°C) (ASTM, 2007). The standard applies to all types of snow-sport helmets, such as full shell, ¾ shell, and full face models. Full face models provide the most protection because they include a chin bar, making them resemble helmets used in ATV riding. Full shell helmets lack a chin bar but still cover the entire head. A ¾ shell resembles a bicycle helmet in that it covers less on the sides of the head when compared to the full shell.

4.2.6 Analysis: Skiing

For the last seven years there has been little change in skiing. The number of participants has decreased slightly with the increase in snowboarding. The types of injuries and body parts being injured hasn't changed. No radical improvements to the technology occurred and none of

the voluntary standards were vastly altered. Skiing injuries, much like the industry, has seen little change, positive or negative.

Despite the lack of change there are still a number of conclusions that can be made drawing from the data. The surveys and the interviews with participant organization representatives yielded similar results. Skiers, it can be concluded, are safety conscious, with a mindset of skiing with control. This means that skiers believe in skiing on terrain that is equal to their level of ability. It is possible that this mindset is the result of the training that a majority of skiers receive when first learning to ski. Beginner skiers usually pay to take a lesson offered by the resort which goes over the basic mechanics of skiing and how to safely navigate the trails. Their training, while not official, usually continues under the guidance of more experienced friends and family. This passing down of information and safe values has possibly contributed to skiers' safety awareness.

As mentioned in the literature review, the estimated percent of skiers wearing helmets has been increasing while the estimated percent of head injuries has not decreased. This might be because those skiers who are being injured have a much higher level of acceptable risk and would probably not be wearing a helmet. Many of the participants that responded to our survey said that they were safe skiers and chose not to wear a helmet. This decision to not wear a helmet could be related to the safe skier mindset, where the skier believes that if he or she obeys the rules and maintains control, then there is no need for him or her to wear a helmet.

The focus on helmets and head injuries is good because it attempts to mitigate the source of severe injuries, but it might ignore the most common source of injuries. In the 25-64 year old age range, where a majority of ski injuries occur, strains and sprains made up about 40% of all injuries between 2000 and 2005. Since the majority of strains and sprains are knee related, a new injury mitigation strategy might be needed with a focus on knee sprains. The same could be done for younger participants in the 15-24 age cohort and with regard to lower leg fractures. Fractures make up nearly 40% of these injuries and those are primarily lower leg fractures. Since the knee and the lower leg are connected, perhaps such injuries could be mitigated by the same process.

4.3 SCUBA Diving

Our group's findings for SCUBA diving were gathered from a combination of two participant organization representative interviews, seven graphs, 40 IDIs, 50 survey responses, and three voluntary standards

4.3.1 Participant Organizations: SCUBA

Representatives from a SCUBA instructor association and participant organization were contacted. The instructor association is national and the participant organization is regional.

- The National Association of Underwater Instructors (NAUI) is composed of members of at least an instructor level of certification. NAUI offers a wide variety of certification outside of basic certification, including air nitrox diving, search and recover diving, cave diving, and many others. In addition to SCUBA diving, NAUI also promotes sponsored coastal cleanups.
- The Ohio Council of Skin and SCUBA Diving Inc. (OCSSDI) is a participant organization comprised of about 300 members between 18 Ohio clubs. OCSSDI also offers a professional membership for SCUBA shops, tour operators, and other organizations. In addition to SCUBA diving, the OCSSDI raises money for memorial scholarships (for students pursuing marine biology or underwater archaeology) and also hosts coastal cleanups.

The missions of these two organizations are slightly different to appeal to a different audience.

NAUI's mission is to "support and promote dive safety through education" (NAUI, 2007).

When the OCSSDI was created in 1959, their original mission was to "oversee training standards for SCUBA enthusiasts and to govern inter-club competitions". Their mission was modified in the 1990s to meet the needs of incoming members, and now includes "providing a unified voice for Ohio's divers in legislative matters".

Although SCUBA diving is a self-regulating activity, both organizations take different approaches of protecting divers. NAUI relies on their extensive certification programs to properly educate divers while the OCSSDI integrates legislation into SCUBA diving to help keep divers safe. Ohio has a Dive Flag Law and a Shipwreck and Salvage Law, educating boaters and divers to help prevent dangerous situations. In addition, the OCSSDI representative mentioned that they are attempting to get legislation for easier and faster access to pure oxygen (O₂) to help divers that suffer from decompression sickness.

Compared to ATV riding and skiing, there were only a few injury cases. A NAUI representative mentioned that injuries rarely occur in SCUBA diving and there is no common type of injury, however, the OCSSDI representative said that the most common injury in SCUBA diving is barotrauma, caused by poor equalization of pressure in the ears. As for the causes of diving injuries, the NAUI representative mentioned that a lack of education results in divers getting injured and that as long as divers are educated, they will not likely be injured. The OCSSDI representative commented that injuries are a result of participants not following the rules or performing above their limitations. While the OCSSDI does not offer training, they promote safe diving and recommend training through other organizations. The OCSSDI representative added that because the diving groups are small, the divers will be more open to discussions and warnings from their peers. This system of checks and balances helps prevent injuries among diving groups.

4.3.2 Injury Data: SCUBA

The number of SCUBA injuries reported to the NEISS database over the past 7 years is fewer than 60 per year. Because of this, the NEISS estimates, shown in *Figure 29*, are relatively low numbers, with an average of 1,500 estimated injuries per year. Unfortunately, the error bars thus make it difficult to judge an increase or decrease in injuries. Even with the error bars, it can be stated that SCUBA diving has a very low number of recorded injuries compared to the other activities.

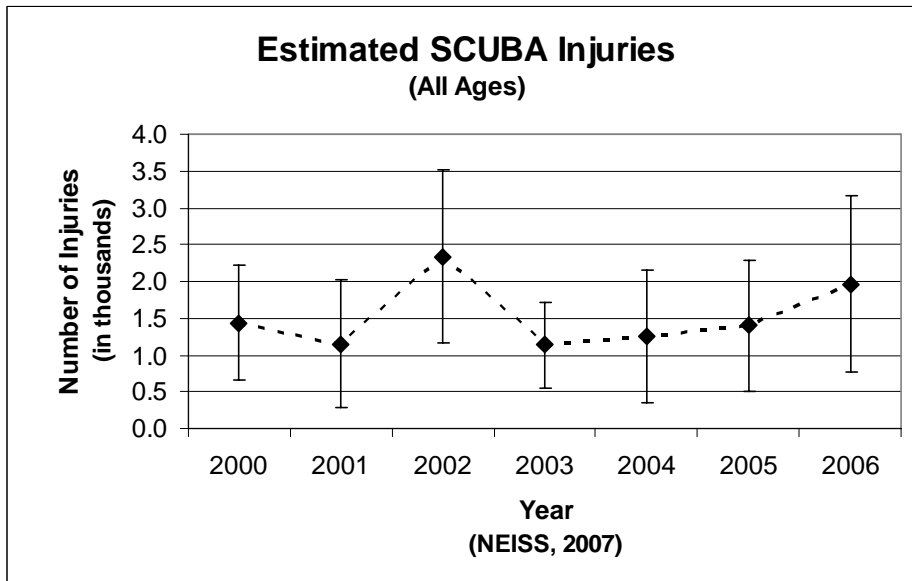


Figure 29: Estimated Scuba Injuries

Figure 30 shows NEISS estimates of the percent of scuba injuries by age group as well as gender. The gender deviation of injuries is biased towards males in almost all of the age ranges. The highest percent of injuries occurred in the middle age range, reaching a peak at ages 30-34 and a smaller peak at 40-44.

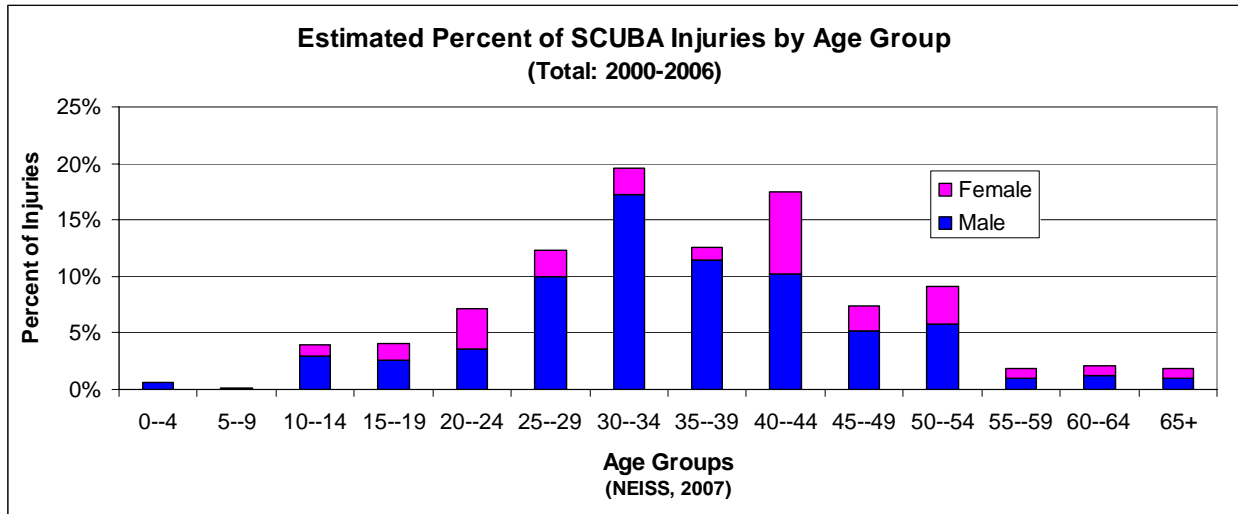


Figure 30: Estimated Percent of SCUBA Injuries by Age Group: N=270

Figure 31 reveals NEISS estimates of the level of treatment with respect to each type of injury. The most common injuries grouped with the “Other” injury type includes barotrauma, an injury caused within the ear and lungs due to poor pressure equalizations during ascent and descent, and decompression sickness, a condition where there is excess nitrogen in the body. Other, less common, injuries classified as “Other” includes otitis, cellulitis, perforation, air embolism, pain in a body part (ear, chest, upper arm), epicondylitis, ear infection, seizure, and tympanic membrane injury. A large portion of injuries, over 55%, were caused by barotrauma and decompression sickness. In addition, the “other” injuries were the only type of hospitalized injuries. According to the NEISS estimates, the other types of injuries made up a very small portion of the total number of SCUBA injuries compared to the “Other” injuries.

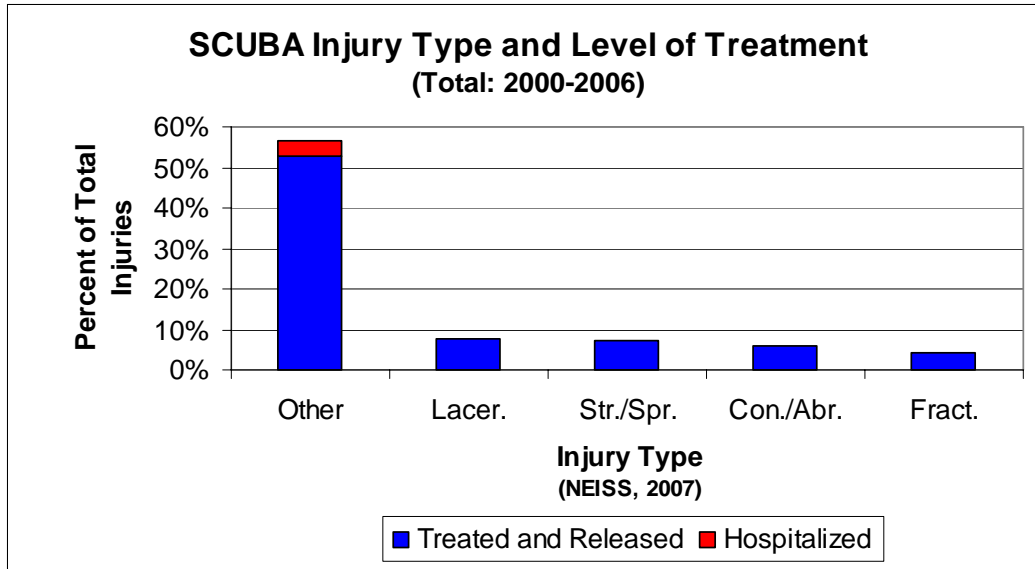


Figure 31: SCUBA Injury Type and Level of Treatment: N=232

Figure 32 illustrates the NEISS estimates for of the level of treatment with respect to each body part. Like before, NEISS estimates show a majority of the injuries are focused within the ear, which required almost no hospitalization, whereas all of the other body part injuries were only a small portion of the total number of injuries. The NEISS estimates of toe, eye, and foot injuries were comparable to other body part injury estimates that were not shown in Figure 32; lower trunk injuries (not shown) make up 3.5% of the total NEISS estimated SCUBA injuries while feet injuries were 3.8%.

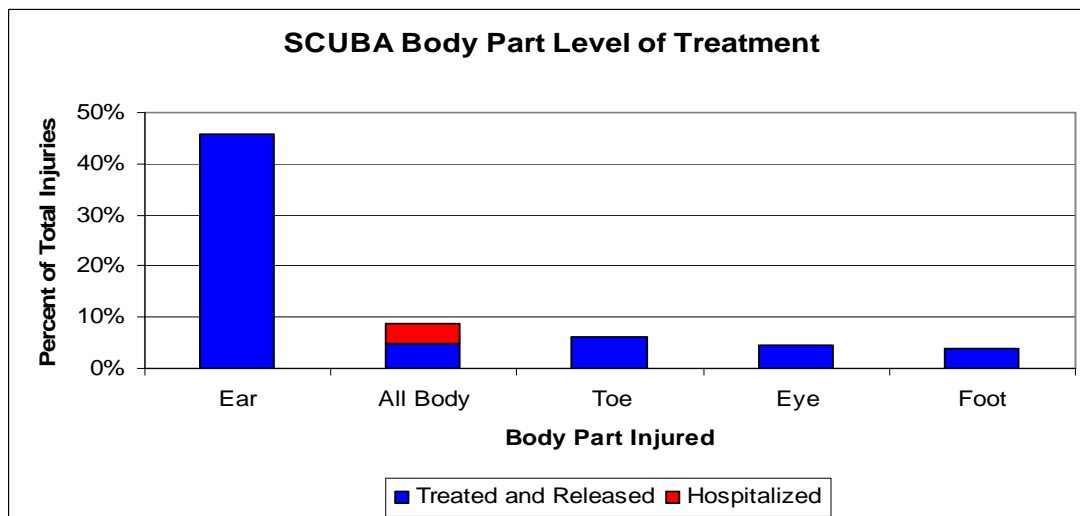


Figure 32: SCUBA Body Part and Level of Treatment: N=182

Figure 33 compares NEISS estimates of the most common types of injuries and body parts injured. Injuries in the ear made up over 60% of “other” injuries, due to barotrauma. In addition, all body injuries were only caused by “Other” injuries, mainly decompression sickness. The other injury types were only a small number of the total NEISS estimate injuries; the biggest concern in SCUBA-related injuries is barotrauma within the ear.

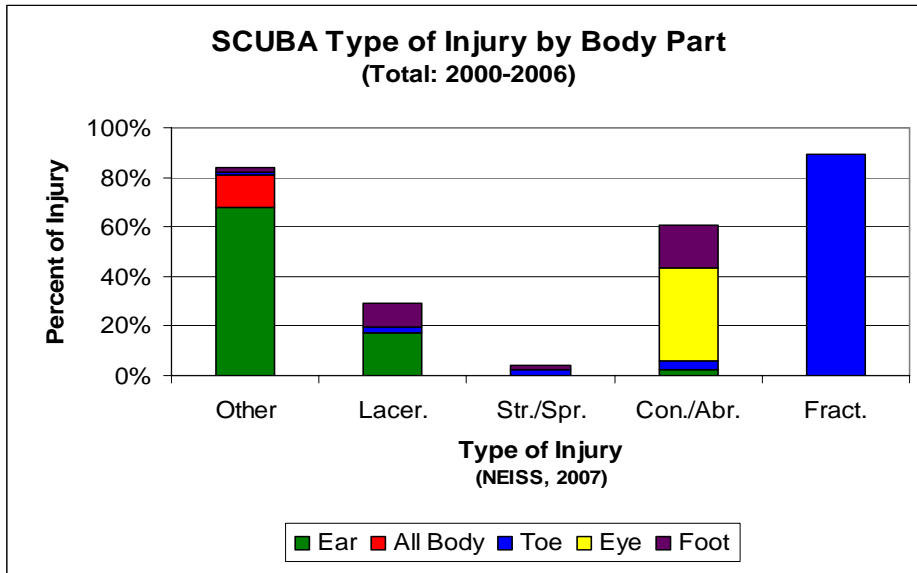


Figure 33: Scuba Type of Injury by Body Part: N=157

Figure 34 compares the NEISS estimates of the most common injured body parts associated with the age range from 25 to 64. The other age groups were omitted due to a small sample size. Ear injuries were the most prevalent within this age group, averaging about half of all injuries. In addition, all body injuries made up a small portion of injuries throughout the seven recorded years while some injuries are not visible in certain years. This shows that while the ear is a commonly injured body part, all body injuries are just as important due to the likelihood of decompression sickness, a leading cause of death.

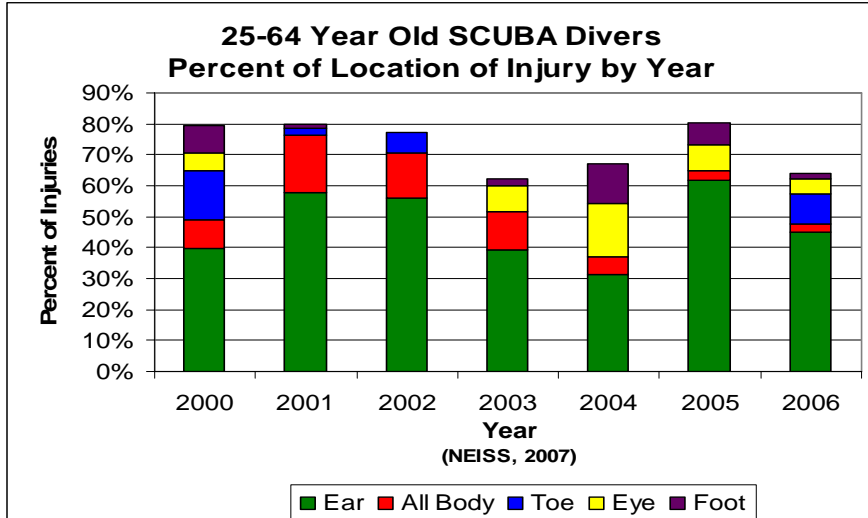


Figure 34: 25-64 Year Old SCUBA Divers, Percent of Location of Injury by Year: N=196

Figure 35 shows the NEISS estimates of the most common type of injury within the same age group. “Other” injuries (barotrauma and decompression sickness) ranged from 40-70% throughout the seven years while all of the other types of injuries were not as prevalent. Because “Other” injuries are the most common, divers should be aware of the issues of quick ascent and proper pressure equalization of the ears.

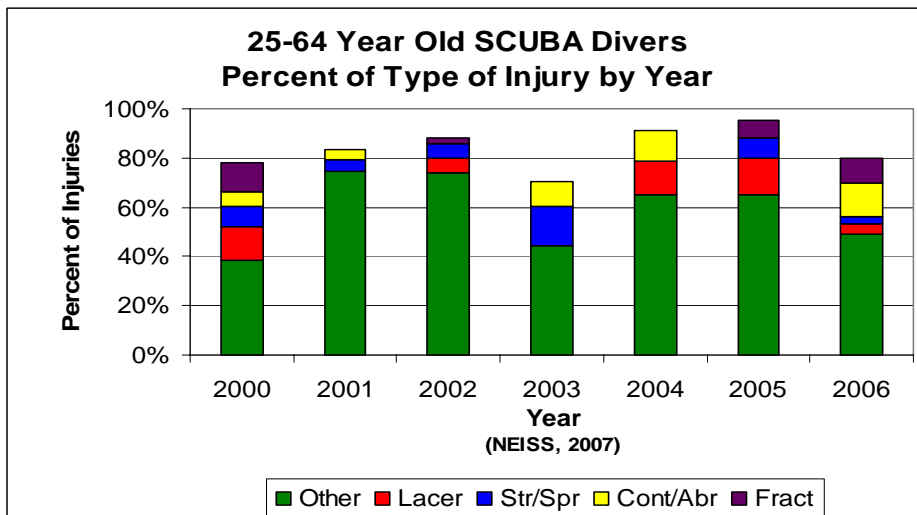


Figure 35: 25-64 Year Old SCUBA Divers, Percent of Type of Injury by Year: N=195

4.3.3 IDI results: SCUBA

There were 40 IDIs available in the CPSC database. Unfortunately, a majority of them did not have any leading conditions that may have contributed to the incident; the only known cause of death in the unknown cases was drowning. There were also many unexpected health problems, such as heart issues, occurring with healthy divers. Outside of the unknown cases, a common condition of an incident was faulty equipment, such as air leaks, incompatible gear, or a lack of maintenance. Faulty equipment seemed to be a condition in eight IDI cases. Because of the aquatic environment of SCUBA diving, if a diver experiences equipment failure and is unable to communicate with his or her group, or is separated from the group, the diver will likely drown or get barotrauma due to a quick ascent to get air. Equipment failure was responsible for a high number of quick ascent conditions, which was found in five IDIs. Some other conditions included poor weather conditions, where waves would separate the victim from the group, diving alone, panic, and drug or alcohol involvement. There were only two cases out of the 40 IDIs where a diver was known to not have certification

4.3.4 Participant Surveys: SCUBA

Through the distribution and collection of surveys, a great deal of information was learned about the attitude and behavior of SCUBA divers. The surveys were distributed to three participant groups, which were: the Olney Adventure SCUBA dive club, the Atlantis dive club, and to a large group of participants linked to a local dive shop. Roughly 300 surveys were distributed to these groups and 50 responses were received, roughly a 17 percent response rate. Although this is a good response rate, this data is not representative of the entire population of participants.

The two topics that were investigated by this survey were: the amount and type training participants thought was necessary and their views towards safety equipment. These two factors were important because they show the participants' attitude towards the risks involved with the activity and how they are dealt with.

By analyzing the survey responses about training, it was found that not only have all respondents received a basic certification, but the majority have gone on to pursue many other specialized types of training. Also all respondents believed that a child should learn how to dive from a professional and experienced instructor. There were also a large number of participants

who believed that personal, one-on-one instruction with a child will help them to better learn and practice the proper techniques. It was also shown that the respondents believe that children should be brought into diving as early as possible, which, as stated by a voluntary standard, is 10 years old.

The second fact that was demonstrated by the survey was that the participants use a great deal of safety equipment. This gear includes: spare tanks, extra regulators, buoyancy compensators, and dive computers. This safety equipment, as well as others, is used by more than three-quarters of respondents. Not only do these participants use this equipment, but they perform yearly maintenance in order to keep their equipment in good working order.

The respondents were also asked to rate, based on their perception, which of the chosen activities had the highest, high, moderate, and lowest amount of risk involved. The options were ATV riding, SCUBA diving, skiing, and rock climbing. Of the survey participants, about one third stated that ATV riding had the highest level of risk; about one third stated that rock climbing had a high level of risk, about one third stated that skiing had a moderate level of risk, and a little over one third stated that SCUBA diving had the lowest level of risk.

4.3.5 Voluntary Standards: SCUBA

While SCUBA diving did not have any standards issued by ANSI, ASTM, or UL, there are three international standards issued by the International Standards Organization (ISO). Two voluntary standards have requirements to attain a certain level of diving skill. The scope of ISO24801 is that a diver must complete training to become certified. There are three different versions of this standard representing a different requirement level for a supervised diver (ISO24801-1: Recreational Diving Services), an autonomous diver (ISO24801-2: Recreational Diving Services), and a dive leader (ISO24801-3: Recreational Diving Services). The scope of ISO24802 is that an instructor must earn certification. This voluntary standard has two different levels of instructor certification (ISO24802-1: Recreational Diving Services, ISO24802-2: Recreational Diving Services). These voluntary standards ensure that divers will get an adequate education as well as proper training to ensure their safety. The third voluntary standard (ISO24803: Recreational Diving Services) specifies that service providers must be proficient in training and education, organized and guided diving for certified divers, and rental of diving equipment. This standard helps ensure that all SCUBA dealers are knowledgeable in certification as well as the equipment being used.

4.3.6 Analysis: SCUBA

The most common ages of injured divers were adults in their 30s. Only a few injuries were recorded by children and teenagers. This could be related to the time commitment required to earn a diving certification or the cost of the equipment and training. However, there is no concrete reason for the age peak from the NEISS estimates. The cost of equipment, maintenance, and training is comparable to ATV riding; a full set of SCUBA equipment and basic training can cost about \$4,000 while an ATV's price ranges from \$5,000 to \$10,000. These estimates do not take into account higher levels of training for SCUBA diving and maintenance for all of the equipment.

The biggest concern for an incident is barotrauma and decompression sickness. The NEISS data showed that ear injuries were the most prevalent while injuries to the toe, eye, and foot were just as uncommon as other body part injuries, which are not shown. The frequency of ear injuries is validated by the OCSSDI representative; he mentioned that ear injuries are the most prevalent type of injury in SCUBA diving. In addition, the NAUI representative believes there is no common type of injury. Because NAUI is an instructor organization, they focus on training participants on how to be safe, including proper equalization in the ears to prevent barotrauma. As a result, any injuries that NAUI may see will unlikely be ear damage.

An interesting aspect of the SCUBA diving IDIs is that a majority of injuries and fatalities were attributed to faulty equipment, which neither representative said was a concern or condition towards injury. This is critical because a malfunction in a piece of equipment may cost a diver his or her life; while a broken dive computer may not do any damage to a diver, a broken regulator or buoyancy compensator may cause the diver to panic or go into emergency quick ascent. Fortunately, many of the survey respondents reported that they perform yearly maintenance on their equipment. In addition, the CPSC staff has recalled several pieces of equipment when necessary. Regulator components, buoyancy compensators, and dive computers are the most common recalls issued by the CPSC staff due to an uncontrolled ascent hazard (CPSC, 2007).

Unlike the other activities, SCUBA has several voluntary standards dedicated to the instruction and education of divers as well as instructors. This emphasis on safety is reflected by the IDIs as well as surveys. From the surveys, not only did all of the respondents report having training, but many of them had level of certification higher than basic. In addition, many

respondents believed that the best method of learning how to dive was with a trainer. Out of the 40 IDIs, only two of the participants did not have certification. Because SCUBA diving has required training, any person who wants to become a diver must be educated in proper diving skills and avoiding hazardous situations. This is supported by NAUI's objective, to properly educate all divers through their extensive training programs. As a result, the frequency of reported SCUBA incidents in the NEISS database is small, as is the perceived total number of injuries projected by the NEISS database, even though the number of divers is speculated to be anywhere between 1.5 to 3.5 million (Davis, 2002). From these points, our group believes that training is an effective way of keeping divers safe.

4.4 Rock climbing

This section contains the results given by the statistical and behavioral research conducted for rock climbing. This section is broken up to illustrate the statistical information given by the NEISS and IDI databases, the goals of the participant organizations and how they are working to accomplish them, and behavioral data from the surveys completed by participant groups. After compiling the data from these sources, an analysis was conducted in an attempt to make correlations between the statistical and behavioral trends noticed throughout the data. Through these comparisons, it was possible to analyze the types and location of injuries, what behavioral factors could possibly be causing these incidents, and possible ways to mitigate the risks involved in rock climbing.

4.4.1 Participant Organizations: Rock Climbing

Representatives from one national rock climbing instructor association and one regional participant organization were contacted.

- The American Mountain Guide Association (AMGA) is composed of about 1300 expert climbers and instructors. There are five types of climbs for which training and certification are offered: rock; alpine; ski mountaineering; climbing wall; and single pitch.
- The Southern California Mountaineers Association (SCMA) climbers participate in various types of climbs, including mountaineering, aid climbing, and exploration/trekking. In addition to climbing, members of the SCMA also do volunteer work.

The mission statements of these two organizations are similar: to promote rock climbing as well as safety.

The SCMA has an extensive training program, the Novice Training Course (NTC), to train novice climbers. The NTC teaches several aspects of rock climbing over several months, including basic knots and rope handling, climbing methods and techniques, and climber signals and communication. To get certified by the SCMA, the trainees must attend every training session and pass an exam.

As is the case for the other activities, there are several reasons why an injury can occur. The SCMA representative says injuries commonly occur during repelling, when a climber pushes away to descend. If the equipment is not properly set up, it can detach from the harness and cause a person to fall. Other causes of injuries are when a leader leaves his stand, which puts the climber in a solo climb situation, and during a pendulum fall, when the climber loses his or her footing. The AMGA representative was not knowledgeable about injury causes, so he did not comment.

There were several suggestions mentioned to prevent injuries. The SCMA representative said a climber should always be “in the moment”; a climber should be aware of his or her actions and think of the consequences. For example, if a climber forgets to check the equipment before repelling, it could cause the climber to fall to his or her death. Because of this, the SCMA representative added that rock climbing is not a forgiving activity. The AMGA representative commented that communication during climbs helps reduce the likelihood of injury.

Both organizations have taken preventative measures to reduce the likelihood of injuries. The AMGA has a Code of Ethics, available on their website, which describes the responsibilities of the climbers and the leaders (AMGA, 2007). The Code of Ethics explains that a guide must be able to inform all clients about safety protocols and how to exercise safe climbing. The Code of Ethics also mentions that any guides must not put themselves in unnecessary danger, such as climbing above their abilities. The SCMA representative mentioned that they have a safety committee that monitors any unsafe behaviors to ensure that climbers do not put themselves in dangerous situations.

4.4.2 Injury Data: Rock Climbing

Over the past few years the number of rock climbing injuries has remained relatively constant, which is shown by the NEISS estimates in *Figure 36*. There is not enough information to state that there is a trend due to the variance represented by the error bars in *Figure 36*.

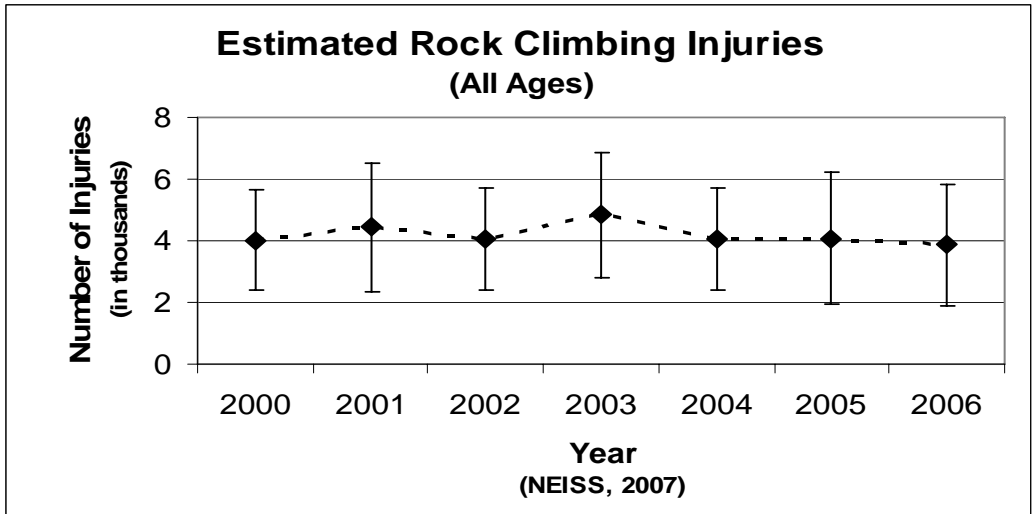


Figure 36: Estimated Rock Climbing Injuries

The research question regarding age and gender separations in the injury data was investigated in rock climbing to determine if there were trends in this data as well. The NEISS estimates in *Figure 37* revealed that the majority of injuries occurred between the ages of 10 and 29, much like in ATV riding. These data also illustrated that the majority of rock climbing injuries occurred with males, except in the 10 to 14 year old range where there is a much better distribution.

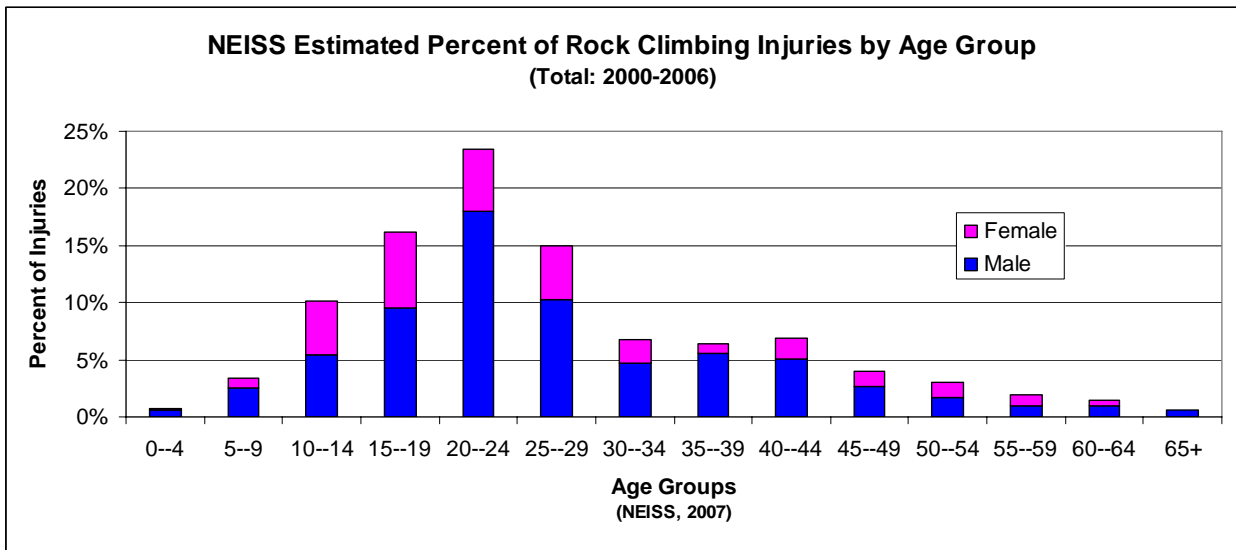


Figure 37: Estimated Percent of Rock Climbing Injuries by Age Group: N=661

The database was again filtered in order to determine the top five injury types. These data were then converted into percentages of the total number of injuries. One example of this, shown by the NEISS estimates in *Figure 38*, is strains and sprains, which make up more than 25

percent of all injuries. These data can be further broken down by the level of treatment necessary, which is also shown by the NEISS estimates in *Figure 38*. Fractures are the second most common type of injury, but they are the only type involving a significant amount of hospitalization.

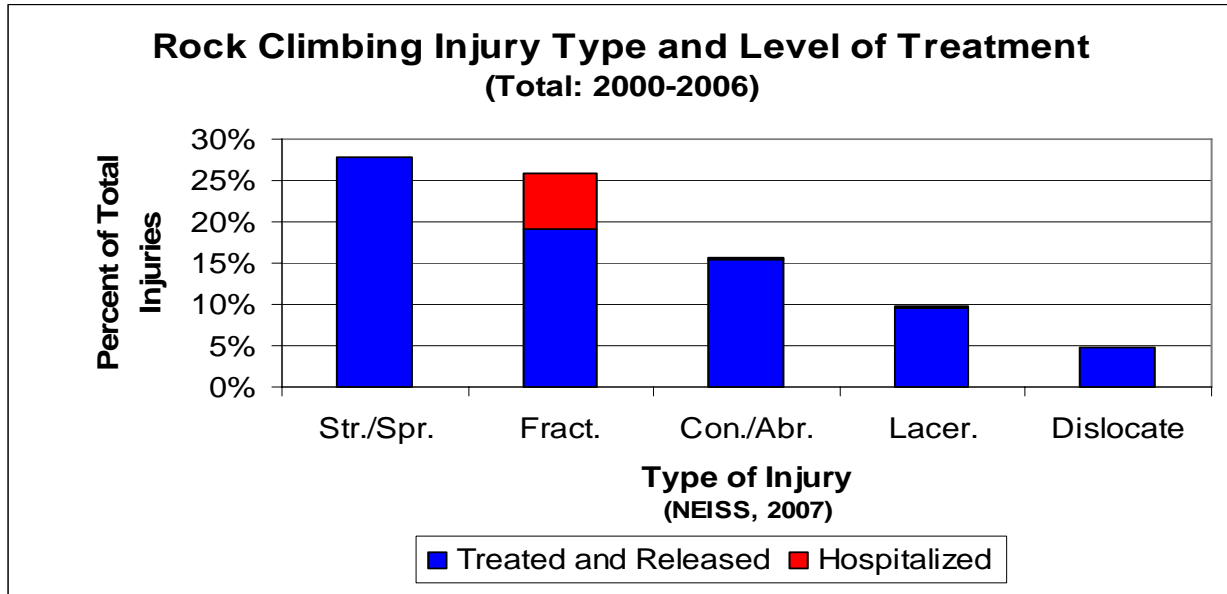


Figure 38: Rock Climbing Injury Type and Level of Treatment: N=550

The database was then filtered in order to find the top five body parts that were injured. The NEISS estimates, illustrated in *Figure 39*, showed what type of injury was most prevalent and what percentage of the total number of injuries they represented. This was broken down much like *Figure 39*, to show the level of treatment that was necessary. For example, ankle injuries represent the highest percentage of injuries, but lower trunk injuries require the largest number of hospitalizations.

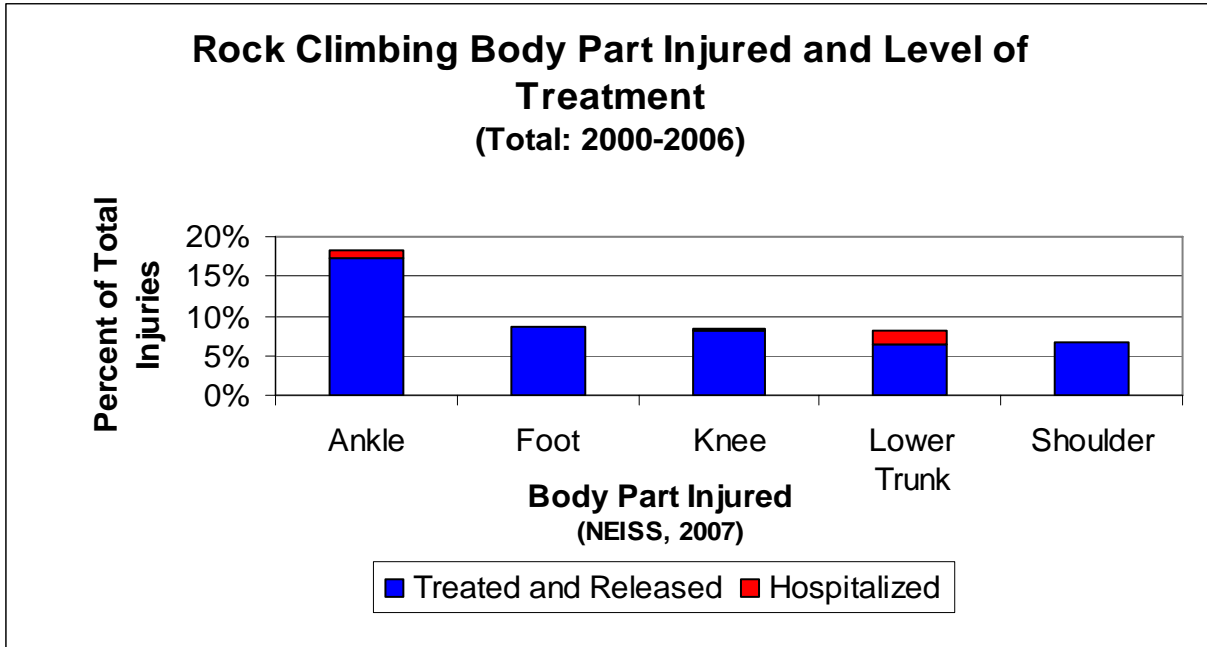


Figure 39: Rock Climbing Body Part Injured and Level of Treatment: N=339

Using the NEISS database, we were able to break down each injury type into what body part it most commonly effects, as shown in the NEISS estimates in *Figure 40*. This allows us to better examine the data and identify the problem areas. *Figure 40* illustrates that ankle injuries make up 40 percent or more of the strains and sprains and shoulder injuries make up around 90 percent of dislocations. One explanation for these high numbers is that these body areas hit the ground first when falling from any height.

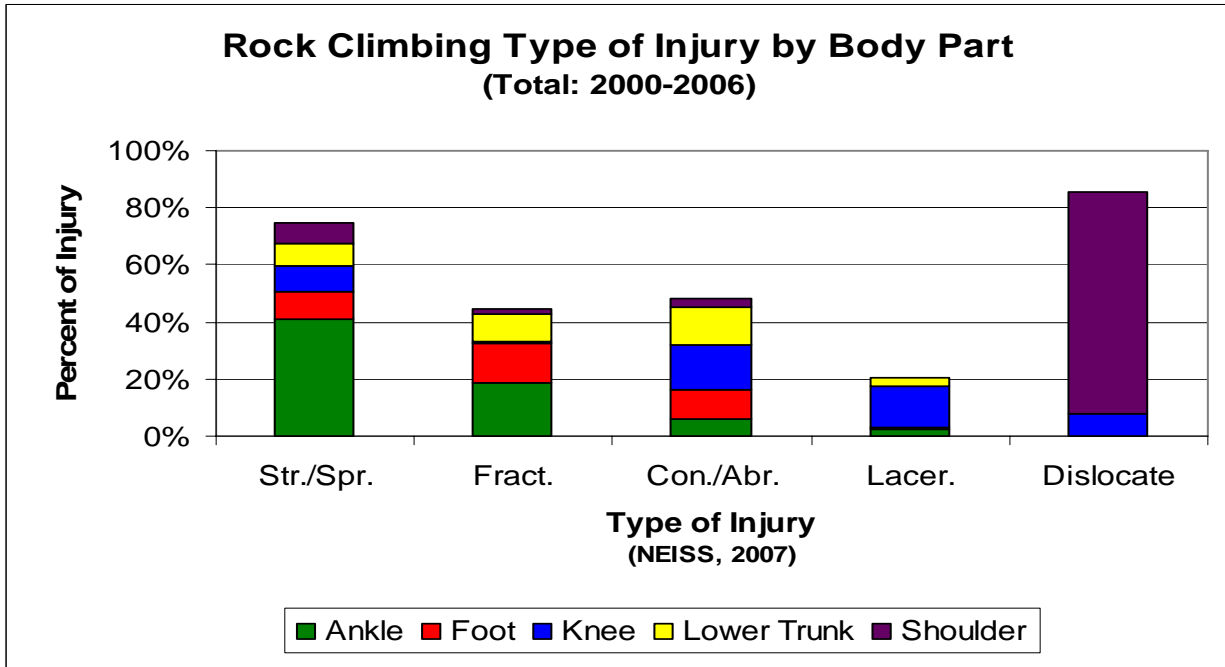


Figure 40: Rock Climbing Type of Injury by Body Part: N=306

The age categories were then filtered to determine the injury type and body part. In *Figure 41*, the data has been broken down to determine the NEISS estimates of what type of injury occurs most in participants age 15-24 every year. These bars do not equal one hundred percent because they only represent the percentage of injuries of that type that occurred in that year. One trend that is illustrated by *Figure 41* is that from 2001 to 2006 strains/sprains and fractures make up almost 60 percent of the total number of injuries in this age group. The other three injury types make up a relatively small percentage of the total number of injuries except for contusions/abrasions in 2000 and 2003.

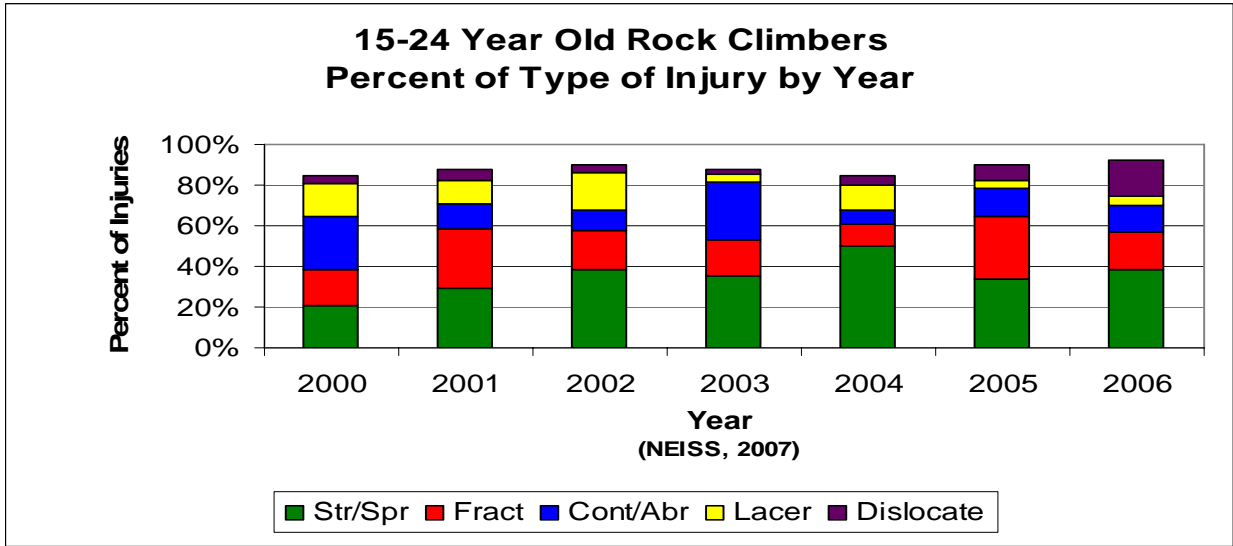


Figure 41: 15-24 Year Old Rock Climbers, Percent of Type of Injury by Year: N=562

The NEISS estimates in Figure 42 are broken down in much the same way as Figure 41, but are now broken down by the bodily location that was injured instead of the type of injury. From analysis of this data, it was noticed that ankle injuries have been steadily increasing since 2001 and in 2006 made up almost 40 percent of the total number of injuries.

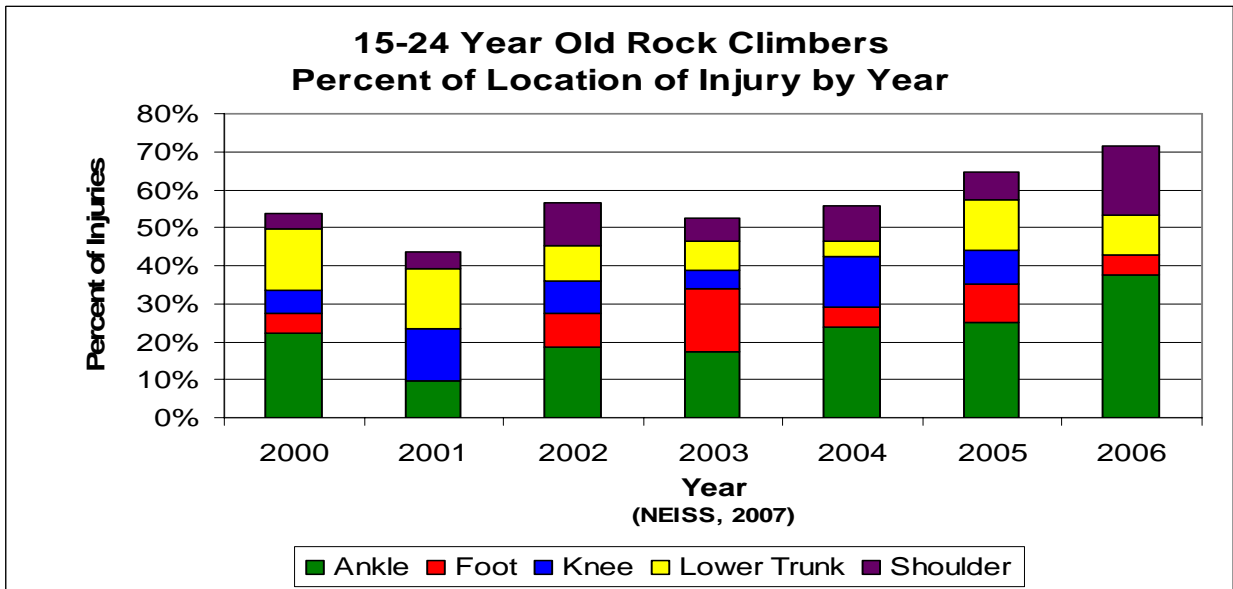


Figure 42: 15-24 Year Old Rock Climbers, Percent of Location of Injury by Year: N=340

4.4.3 IDI Results: Rock Climbing

In rock climbing, there were only five IDIs. Two incidents were from human error, which resulted from improperly setting up equipment as opposed to an equipment failure. In both cases, the equipment disengaged from the climber, which resulted in a fall. These were not classified as equipment failure because the equipment was considered properly functional. One incident was caused by equipment failure due to a manufacturer flaw. Two other IDIs dealt with a person attempting to go beyond their ability; one climber did not have a harness and another climber attempting to climb down a wall at a fast speed slipped and fell.

4.4.4 Participant Surveys: Rock Climbing

Through the distribution and collection of surveys, a great deal of information was learned about rock climbers' opinions towards safety and risk. The two topics that were investigated by this survey were: the amount and type training participants thought was necessary and their views towards safety equipment. These two factors were important because they demonstrate the participant's perception of the risk involved with the activity and how they are mitigated.

This survey was distributed to one rock climbing group, which was the Cornell Outdoor Education class, as well as other non-affiliated climbers. This survey received roughly a 33 percent response rate, 20 out of the 60 participants who were given the survey. Although this is a high response rate, it cannot be stated to be a representative sample of the entire population due to its small sample size.

Analysis of this survey gave a great deal of information regarding the safety gear used in the activity. It was shown that roughly two-thirds of survey participants wear a helmet while climbing and also employ a number of other safety devices. For example, harnesses, ropes, and shoes are used by more than three-quarters of those who responded. When asked if the gear on the market today is good enough, all respondents answered yes, which shows that they feel safe using the gear that is available. One possible explanation for this is the familiarity that is developed with this gear through the training process.

By looking at the data given by the surveys, it is shown that roughly two-thirds of the respondents attended a training course of some kind. By comparing this information to that

given by the training questions, it is shown that the ratio of participants that use helmets is equal to that of those who have taken a training course. One possible explanation for this is that the use of helmets is stressed during these training courses. However, when asked how a child should learn how to climb, only one-tenth of the participants recommended a course run by a trained instructor. Also, when asked at what age a child should be allowed to climb, more than three-quarters said under the age of 10.

The respondents were also asked to rate, based on their perception, which of the chosen activities had the highest, high, moderate, and lowest amount of risk involved. The chosen activities were: ATV riding, SCUBA diving, skiing, and rock climbing. Of the survey participants, about one third stated that ATV riding had the highest level of risk; about one third stated that skiing had a high level of risk, about one third stated that SCUBA diving had a moderate level of risk, and a little over one third stated that rock climbing had the lowest level of risk.

4.4.5 Voluntary Standards: Rock Climbing

Since the 1970s, the American Society for Testing and Materials (ASTM) has been working to develop a set of testing standards for the equipment that is used in rock climbing. These standards were developed based on the International Mountaineering and Climbing Federations guidelines on the amount force that the ropes and carabineers must be able to withstand, which are 12kN and 20kN respectively. These numbers were taken from a study done by paratroopers that showed "...that the human body in a harness could sustain a 12kN force of short duration without injury" (ASTM, 1999). One example of a standard is ASTM-F1774-99, the Standard Specification for Climbing and Mountaineering Carabineers. This standard clearly explains the conditions and procedures for six mechanical tests, as well as a performance test to ensure that a carabineer is properly designed for climbing and mountaineering. One example of a mechanical test that is performed is the gate test. In this test, experimenters place a force on the carabineer and check if the gate or latch will still function properly. Experimenters also perform an overall performance test to make sure that the carabineers and harnesses being tested are able to withstand the proper amount of force without failing.

4.4.6 Analysis: Rock Climbing

By combining the data that was found by our research, it was possible to determine patterns and trends based on the information given by the five sources researched. Our group was also able to determine some of the possible causes of the injuries and mitigation strategies that have been developed by the participants of the activity

The first aspect that our group compared was the training. From the interviews conducted with representatives from participant organizations, we learned that the safety aspect that is stressed most is proper training. According to our surveys, roughly two-thirds of respondents had received some type of formal training. This shows that these organizations are effectively marketing the training. The effectiveness of the marketing strategy and the willingness of the participants to attend training courses could be a possible reason why the number of injuries is relatively low. These training courses could also be the reason why so much safety equipment is used. Through the training process participants are taught not only the correct techniques needed for safe climbing, but also the proper use of the climbing gear. The results of the survey data showed that roughly two-thirds of participants use a harness, shoes, and ropes while climbing. When survey participants were asked if the safety gear on the market today was adequate, all responded that they believed it was. One possible explanation for this is the voluntary standards that are in place to test and certify climbing gear.

4.5 Activity Comparison

One of the goals of research was to make comparisons between the four HARAs our group researched. In most cases the data for each activity must be displayed on its own graph due to the differences between them. In this section we have created a graph that compares the bodily location of injuries among the activities and another that compares the level of treatment required by injuries sustained in the activities.

The NEISS database has numerous body parts listed as search options. In the previous sections the data were filtered to include only the top five most commonly injured body parts. To properly compare the injured body parts in each activity our team used every available NEISS body part search option and then grouped the options by what section of the human body they belonged to; legs, arms, torso, and the head and neck, as shown in *Figure 43*. This comparison covers all of the NEISS estimated injuries for the activities between 2000 and 2006.

ATV injuries were distributed about equally across each section of the body. Skiing has a slightly larger percentage of leg injuries than ATVs, but otherwise its distribution is very similar. This could be because ATV injuries and skiing injuries are either collision or speed related. A majority of SCUBA injuries afflicted the head and neck. This is because a majority of SCUBA diving injuries are ear injuries, more commonly known as barotraumas. Skiing and rock climbing were similar in the fact that leg injuries made up the largest percent of injuries in both activities.

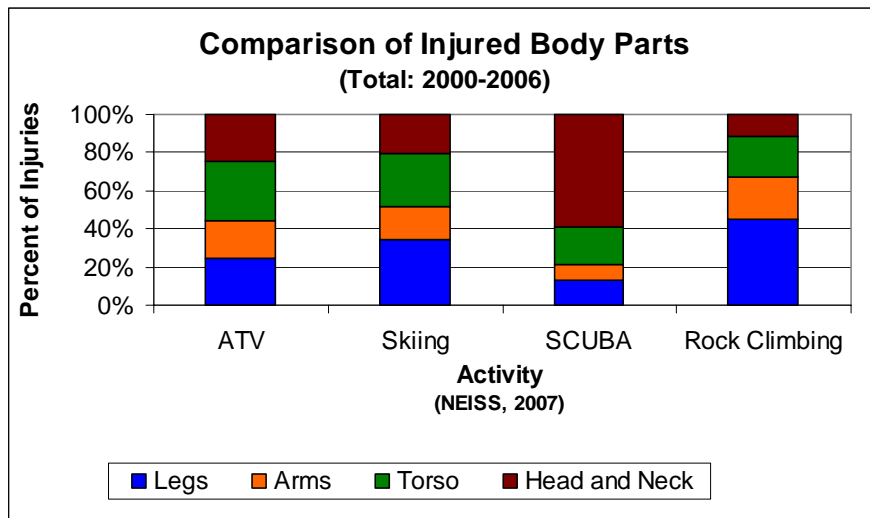


Figure 43: Comparison of Injured Body Parts: N=30605

Figure 44 is provided to show the differences between the population as a whole and its distribution by age and gender, as compared to that portion of the population injured in HARAs. The population of the U.S. is monitored by the U.S. Census Bureau (US Census Bureau, 2007). They are able to provide projections about the demographics of the U.S. Below in Figure 44 is the chart generated using their estimates for 2006 for the percent of the population in each age bracket as well as what percent is male and female in each age bracket. Males and females are nearly equal until age 50 after which females make up a larger percentage of the age brackets. The age ranges below 40 are nearly equal at just under 7% of the population. There is a slight increase in the 40-50 year old ranges because of the baby boomers. This is included in our research in order to better show the disparity between the numbers of males being injured compared to the number of females and the numbers of youths being injured in HARAs compared to the number of adults.

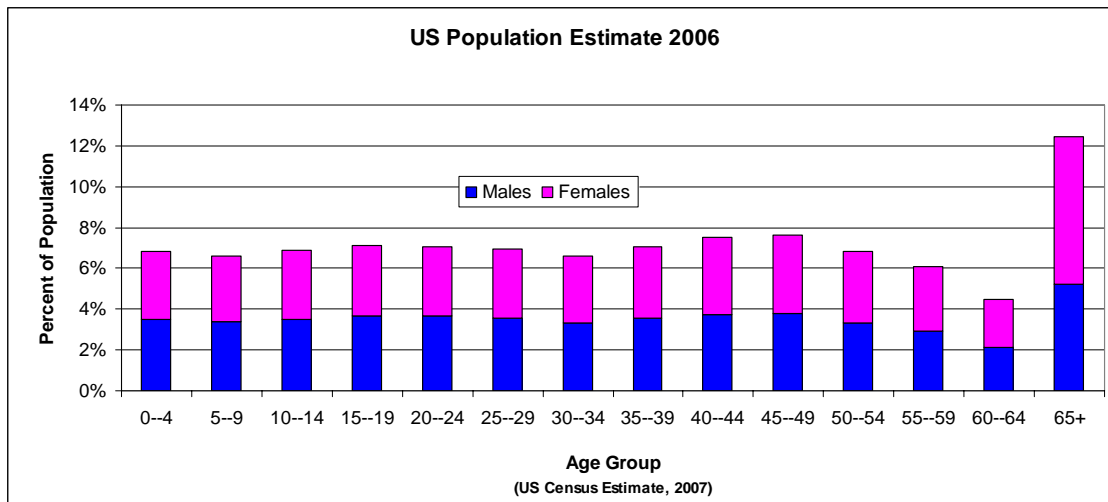


Figure 44: US Population Estimate for 2006

In order to better compare the level of risk involved with each HARA, it is important to understand the severity of the injuries associated with the activities in addition to the rate of injury. The NEISS database categorizes the level of treatment a person receives. The categories are; treated and released, hospitalized, treated and transferred, and held for observation. Since treated and released made up such a large percentage of the injuries, the other categories were summed together under the label *hospitalized*. From Figure 45 it is evident that ATVs have the highest number of injured participants, followed by skiing, rock climbing, and lastly SCUBA diving. The differences in the number of participants treated for injuries are great when comparing ATV injuries to the others. Even skiing, which has a similar number of estimated participants when compared to the estimated number of ATVs in use, has less than half the total number of participants injured, of which a much smaller percent required hospitalization. SCUBA diving and rock climbing have about a third as many estimated participants as ATV riding has units estimated in use, but both SCUBA diving and rock climbing have much less than a third as many injuries.

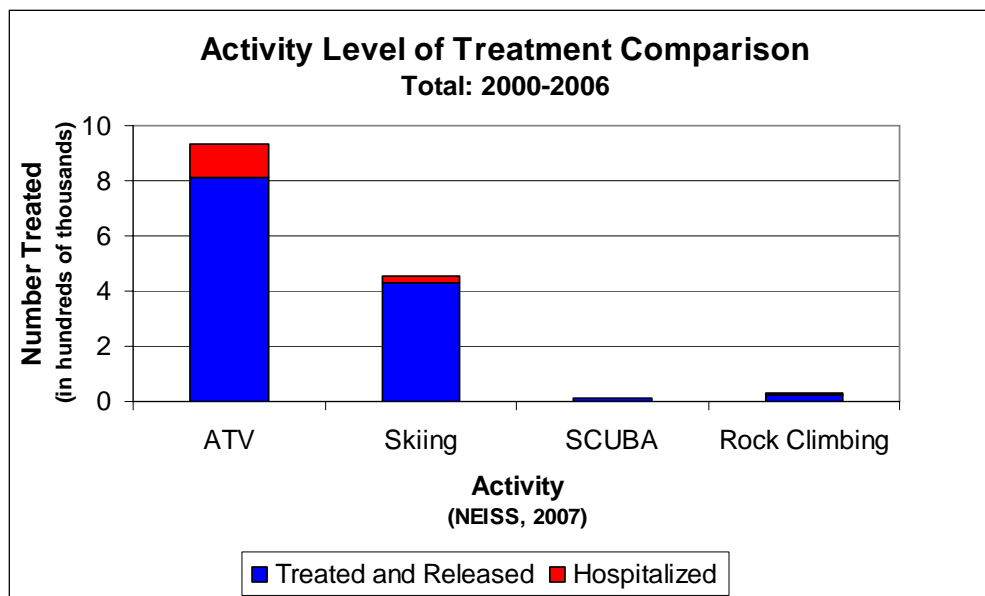


Figure 45: Activity Level of Treatment Comparison: N=30605

Table 4 represents the estimated number of participants for each activity with the NEISS estimate averages of participants injured, according to Figures 17, 23, 29, and 36. The number of participants in each activity is a highly speculative number, but these estimates allow a rough comparison of the level of risk in each activity. The number of ATV riders is based on a CPSC estimate of the number of ATVs in use as of 2005 (CPSC, 2005), with a one-to-one ratio of ATV riders to ATVs. The number of skiers is based on the NSAA estimates as of 2007 (NSAA, 2007). The number of SCUBA divers is based on Undercurrent's 2007 estimate of active divers who dive at least five times a year (Undercurrent, 2007). The number of rock climbers is based on the National Sporting Goods Association (NSGA) estimates as of 2004 (NSGA, 2004). While these numbers are compared from different years, they provide enough of an estimate to make an interesting comparison: the estimates of injuries per 10,000 participants in the investigated HARAs. There are 200 ATV-related injuries per 10,000 ATV riders and 143 skiing-related injuries per 10,000 skiers while there are only 17 SCUBA-related injuries per 10,000 divers and 11 rock climbing-related injuries per 10,000 climbers. This however is not a complete representation of the level of risk in each activity; there are other factors to be considered, such as how often a participant is involved in the activity and how long the participant does the activity. The data to judge a participant's risk by their level of exposure does not exist at this point.

2003	ATV	Skiing	SCUBA	Rock Climbing
Number of Participants	6,200,000	6,800,000	1,500,000	3,200,000
Number of Injuries** (range)	110,000-160,000	12,500-90,000	500-1,750	3,000-7,000
Percent Injured* (range)	1.77%-2.58%	0.18%-1.32%	0.03%-0.12%	0.09%-0.22%

Table 4: Percent Injured by Participant Number

*estimated numbers

**NEISS estimated numbers

4.6 Behavioral Analysis

A person may think an activity is more dangerous due to a higher level of perceived risk. To gain a better understanding of how people interpret the risk in different activities, representatives from all of the participant organizations were asked to compare the levels of risk involved in two activities, the activity they were proficient with and one other activity (from those in our research). The purpose of this question was to see if the organization representatives perceived their activity as safer than other activities. Of those that provided an opinion, only three of them (LAC, NWSCC, and FVATVA) viewed their activity as safer than other HARAs. Five organization representatives gave very interesting responses, mentioning that the level of risk between activities was not comparable. The SCMA representative (comparing rock climbing to ATV riding) mentioned there is always an inherent level of risk involved, and that a participant should always get adequate training. The VASA representative said that each activity is dependent on a participant's ability. The ATVA representative (comparing ATVs to rock climbing) said while ATV riding may be easier than other activities, it is not necessarily less risky. The OCSSDI representative (comparing SCUBA diving to rock climbing) mentioned that as long as a person pays attention to the rules, any activity can be equally safe. The NAUI representative (comparing SCUBA diving to skiing) said that there is no true comparison between the two activities' level of risk.

Survey respondents in two out of the four activities, 45 percent of SCUBA divers and 37 percent of rock climbers, indicated that the activity they participate in has the lowest level of risk involved. This response could be because the respondent knows what that activity involves, thus they will view it as a relatively safe activity. Outside of the respondents' surveyed activity, SCUBA diving was considered to have the lowest level of risk while ATV riding was assigned the highest level of risk, with rock climbing being viewed as more risky than skiing. These judgments could be based on the fact that ATV incidents are reported in the media, as well as

newspaper articles, more often than SCUBA diving incidents; which correlate with our literature review research of Slovic's psychometric paradigm of perceived risk (Slovic, 1987). The only difference is that the rate of injury in ATVs is proportionally higher than SCUBA diving; therefore, it is a valid concern. In addition to the surveys, several participant organization representatives commented that there is no true comparison of risk between the different activities; as long as the participant gets an education in the activity and acts responsibly, the participant should not be at risk.

The CPSC staff believes that social marketing can affect the way a product is used. Examples of social marketing would be impressions created by X-Games or YouTube[®]. Because of this, our group decided to ask participant organization representatives for their opinions about how social marketing could have an effect on voluntarily dangerous actions. Out of all of the participant organization representatives that were interviewed, only two of them gave a response regarding public media. The other organization representatives either did not comment or were not aware of what the X-Games or YouTube[®] were. The ATVA representative said it is "pretty well a fact" that people want to mimic what they see. He added that children are impressionable, and a child's environment can affect his or her thoughts and actions. While the OCSSDI representative opined that media images might be responsible for people putting themselves in unsafe situations.

4.7 Findings Summary

The quantitative and qualitative data collected provided our group with some interesting data. The quantitative data consisted of the NEISS database, which generated estimates about the injuries for each activity. Even though the ranges of the estimates were large in some cases, they remain valuable because they are the most accurate national injury data available. The qualitative data was the organization leaders' interviews, IDI reports, and participant surveys. They provided an outline of how injuries and their mitigation strategies are viewed by each activity's participants. When the two types of data were fully analyzed, our group was able to develop conclusions based on them that proved just as interesting.

5 Conclusions

The goal of this project was to compare the four researched High Adventure Recreational Activities (HARAs) to each other. This comparison was to have been made with the intention of finding factors that mitigated the risk in each of the four activities that could be applied to the other three. However, after reviewing the collected data, the first conclusion our team came to was that the data were insufficient to substantiate an exact comparison. The comparisons are less conclusive than first anticipated.

5.1 Databases

The CPSC databases, which were to provide the statistical backing of our research provided a smaller number of incidents than anticipated. The estimates that our team generated using the National Electronic Injury Surveillance System (NEISS) were not representative of the entire population because the sample used to generate the injury rate estimates was too small. A slight change in the number of injuries reported could have a drastic impact on the resulting estimate. This issue was a factor for all of the activities, which made it difficult to draw conclusions concerning trends from one year to the next. This is because of the wide confidence intervals of the NEISS estimates. For example, a NEISS injury estimate may be increasing over the course of several years, but because the confidence intervals are wide the actual number of injuries could be increasing, decreasing, or remaining constant. The In Depth Investigation Database (IDI) was expected to hold clues that could indicate the causes of injuries and fatalities. However the sample size of the IDI database was even smaller, and could not be used to draw conclusions with any amount of certainty. These problems could not be solved outside of CPSC either; because despite the lack of data within the CPSC, no other government agency or private organization has data comparable to that of the CPSC staff.

5.2 Training

Although the four activities all have training programs, they are not all equally effective. When looking at SCUBA diving, skiing, and rock climbing, a majority of participants have taken a training course. In comparison, a minority of ATV riders took a training course. One possible explanation for this is that the ATV training program is not as widely publicized as programs for the other three sports. For example, when beginning to SCUBA dive, a training course must first

be completed before a dive shop will rent or sell equipment to a participant. When buying an ATV it is not mandated that the consumer take a training course beforehand, but ATV dealers, in an agreement with the CPSC, are supposed to suggest that one be taken. In addition to the basic training programs offered by skiing, rock climbing, and SCUBA diving, there are also specialized training programs for those who wish to further advance their skill level; however, like their basic training courses, these advanced courses for skiing and rock climbing do not result in certification.

Safety gear is an essential part of all of HARAs because they can help prevent injuries. The level of safety gear required varies between the activities, from being optional to being built into the standard equipment. Helmets are strongly suggested with ATV riding, skiing, and rock climbing but are not required. The use of helmets is strongly suggested by participant organizations due to the large number of estimated head injuries in ATV riding and skiing. An example of a safety feature built into the equipment that has been used to help prevent injuries is ski bindings. Ski bindings are set to release automatically if a skier falls or begins to twist with excessive force to prevent leg injuries. Nearly all of the equipment used by a SCUBA diver or rock climber protects the participant. In addition, there are optional pieces of equipment which are available to help prepare for other forms of injury. Optional equipment may include: goggles to help prevent ATV-related eye injuries, a spare breathing regulator (octo) in the event of a broken primary breathing regulator or a dive buddy's equipment malfunction, and rock climbing shoes for better traction.

5.3 Activity Environment

The factors of where, when, and how often a HARA can take place are important because they may limit the amount of exposure participants have to the risks involved with the activity, which may also effect the rate of injury for the activity. Skiing is the most limited of the four activities as to where and when it can be done. Skiing is limited to locations where there is a hill or mountain and has a limited season because it needs snow. ATV riders can be seen in all seasons and in every state. Some participants do choose to bring them on the one location they are prohibited from, paved roads. This is dangerous because the ATV is not designed for use on pavement and the rider must now contend with automobile traffic which is not expecting an ATV to be there. SCUBA divers are limited to bodies of water but there are a significant number of bodies of water scattered across the country. Unless a diver is in continuously warm

climate such as Florida, or properly certified for winter conditions, such as ice diving, divers are also limited by the season. Rock climbers are also limited by the season unless they live in a continuously warm climate or have access to indoor climbing gyms, which operate year round.

After comparing the limitations of where and when these activities take place, the last factor is how often the activity can occur. ATV riders don't have to go farther than their own property in order to ride in many cases. If they are not riding on their own land, they may be using a state or federal park. This gives them the potential to ride every week of the year if they desire. SCUBA divers, skiers, and rock climbers are all more limited in how often they can participate in their chosen activity. An ATV rider can spend as little time preparing to ride as turning the ignition while rock climbers and SCUBA divers do considerable amounts of preparation and safety checks. Skiers, rock climbers, and SCUBA divers must often travel a distance from home in order to participate. These limitations can result in a participant devoting most of a day to just the activity. Most participants can only afford to do this infrequently, further limiting their exposure to the inherent risks in their activities when compared to ATVs. Conversely, these limitations of exposure mean that ATV riders have more opportunities to be practicing and improving their skills than the participants in the other three activities.

Ski resorts have some unique qualities not shared by the other three activities. Large numbers of participants are skiing all at the same time, at large resorts there may be several thousand participants. The other three activities do not come close to the level of traffic seen in skiing. Rock climbing and skiing both have clearly defined rating systems for the difficulty of the trails or climbs. Ski slopes are monitored by the ski patrol, who prevent unsafe behavior and treat injuries. However, the ski patrol does not maintain constant surveillance on all trails at all times due to their limited numbers. At many resorts they can be contacted by anyone with a variable frequency two way radio. ATV trails are not monitored on private land, and there are only occasional inspections by state or federal officials on public land. Rock climbers and SCUBA divers are frequently monitored by a belayer or a dive buddy. Unless they are climbing or diving as a group there may not be anyone with advanced medical certification nearby in case of emergency.

5.4 Injuries

In order to create a successful risk mitigation strategy it is important to know what types of injuries are caused, what age groups are affected most in an activity, and what body part is most commonly injured. By filtering the database, the NEISS estimated number of injuries for each age group was found. Through analyzing these age groups, a majority of injuries were found to be in the 25-44 year-old age range for SCUBA diving, 10-24 for ATV riding, and 15-29 for rock climbing. Although skiing showed a peak much like the other activities, in the 10-19 year old age group, this peak did not make up a majority of the injuries. This does not mean that the participants in these age groups are more likely to be injured because the participant data for these age groups is not available. For example, the rate of injury could be the same for all the age groups if the listed age groups also had the majority of participants as well. When adding up the percentage of injuries for skiing, it was shown that the majority of injuries occurred to participants over the age of 20. One possible explanation for the injury peaks in the younger age ranges is a lack of experience. This applies to all HARAs, but for example, if a 20 year old ATV rider and a 50 year old ATV rider who both started riding when they were 10 were asked if they were experienced it is likely that they would both say yes. They both perceive that they are experienced even though one has 30 more years of experience than the other. This mindset of perceived versus actual experience could be another explanation why younger riders are more likely to take risks that result in injury. Another possible explanation for the peak of ATV riding injuries in the younger age groups is their lack of physical and mental development that is necessary to safely control an ATV. When looking at the data regarding SCUBA diving, one possible reason for the peak being in the older age group than the other activities is because of the level of training necessary. The level of training required may limit the number of children and young adults that are able to participate in the activity.

In addition to the age ranges of injury data, the type of injury was also observed. ATV riding, skiing, and rock climbing all have similar types of injury diagnoses: contusions/abrasions, strains/sprains, fractures, and lacerations. While SCUBA diving has three similar injury types (lacerations, strains/sprains, and contusions/abrasions), they make up a small percentage of injuries when compared to “Other” injuries. For ATV riding, skiing, and rock climbing, a majority of hospitalizations were due to fractures that may have been caused by a collision or by falling. Due to the ATV’s top-heavy design, it is possible for an ATV to flip over and roll onto

the rider, which can cause contusions/abrasions, strains/sprains, and lacerations, in addition to fractures. A skier or ATV rider can get injured by colliding with a stationary object, such as a rock or tree. In addition to collisions, ATV and skiing-related injuries may also be due to speed. For example, a skier or ATV rider trying to make a sharp turn or travel over rough terrain at high speed can result in a collision or fall injury. A rock climber's injuries may be attributed to falling short distances such as when a climber loses his or her grip and is caught by the belayer; the type of the injury is dependent on the distance of the fall.

The body parts injured in the HARAs were also compared. ATV riding and skiing had a high number of head injuries which were shown to be one of the most serious types of injury because a large number of them require hospitalization. In the IDI reports, conditions that may cause head injuries include ATV roll-overs, collisions with a fixed object, and being ejected from an ATV. Lower trunk injuries and shoulder injuries were a large portion of injuries in ATV riding, skiing, and rock climbing. Like head injuries, lower trunk and shoulder injuries may be caused by falling. Knee injuries were also common injuries in rock climbing and skiing. These injuries may be caused by improper footing of the participant, such as skier catching a ski on some ice or debris and twisting their leg, or a climber losing his or her footing and swinging into a rock. SCUBA diving injuries could not be compared with the other three activities because a large number occurred in the ear (~45%).

5.5 Participant Behavior

The way participants interact with each other and how they perceive themselves varies from activity to activity. There are a number of factors that contribute to the manner in which the activity is perceived. ATV riding and skiing both have a sizable presence in the media, targeting young audiences. Experts and professionals can be seen performing tricks and stunts, and are glorified for their accomplishments. Their behavior could be imitated by an inexperienced but impressionable younger viewer resulting in injury. Where an enthusiast goes to shop for equipment can also make an impact on how they view the sport. Specialized shops or dealers who focus on an activity can offer advice and services; such as maintenance, rentals, and sales of equipment with a high level of expertise. SCUBA dive shops are places where lessons can be taken and questions about new equipment or safe dive locations can be asked.

One aspect that rock climbers shared with SCUBA divers was their attitudes towards safety. Both groups have a strong belief in the need for proper instructor certified training.

Skiers believe in training as well, but believe it is less important. Their focus is more on gaining experience and using safe skiing practices. The ATV rider community has the least emphasis on training. This may be due to the fact that they are more individualist and have less of a sense of community with other riders when compared to participants in other activities. Our survey to ATV riders reflects this, in that only a small fraction of those who received it took the time to respond; whereas participants in the other activities were more willing to respond. ATV riders prefer to ride in the manner that suits them best. Whether this involves a helmet or other safety practices is up to the participant to decide. When surveyed on how participants perceive the level of risk involved with their activity when compared to the other three HARAs a majority of respondents for each activity said that his or hers was the least risky. This may be because participants are the most comfortable with the activity they are the most familiar with. For example, if a participant has skied numerous times without injury and tried to compare it with their limited ATV riding experience in which they also were not injured, it is likely they would rate ATV riding as more risky because they are the least familiar with it, even though they were not injured in either activity.

The recommendations that can be made based on these conclusions can only be broad and far reaching generalizations. The lack of sufficient data makes it impossible for a concise and directed approach for reducing injuries or mitigating the risk related to these activities. This is not saying that our recommendations would not have an impact. It's that the process of comparing different HARAs to each other must first be improved before action can be taken that would probably create positive results.

6 Recommendations

As a result of the analyses of data, the following recommendations should be considered by the CPSC staff to mitigate injuries and deaths in HARAs. Our recommendations have been broken down into five categories: database improvements, additional data needed, training, safety improvements, and future projects.

6.1 Database Improvement

These recommendations are to:

- Improve the National Electronic Injury Surveillance System (NEISS) database.
 - Make additional categories that are activity-based and not completely product-based.
 - Divide injury categories into more specific classifications. For example dividing “other” in SCUBA into various injury types such as barotraumas, epicondylitis, and the bends to better define a problem with an activity.
 - Increase the sample size to develop a better and more representative estimate, while maintaining a stratified system.
 - Less than 2% of hospitals in the US are currently sampled.
 - These changes would be very complex and would take a great deal of work to accomplish, but would be very beneficial to the agency. Being able to search this already extensive database by activity would allow for comparisons between activities to be made quickly and easily.
- Improve on/ increase In-Depth Investigation (IDI) database.
 - Increase IDI sample size of other HARAs, such as SCUBA diving and rock climbing, for better comparisons between activities.
 - Investigate new ways to develop more comprehensive causal data.
 - This improvement wouldn’t require significant changes to the database itself, but rather just increasing the number of reports entered into it. The only challenge to this is that it would require investigators already in the field to focus more of their valuable time on this rather than other projects. These investigations should be geared towards finding out all aspects of what led to the incident, whether it was

product related or due to human error. Once the causes of an incident are known, mitigation strategies can be developed and tested.

6.2 Additional Data Needed

- Determine the number participants for each activity.
 - Through our investigation, it was determined that relatively accurate estimates for the number of participants in a majority of the researched HARAs cannot be obtained. Other important information that could not be obtained was age and gender distribution of participants. The reason for this is that no government agency, participant organization, or trade group is able to accurately track the participants in these activities. To try to overcome this lack of information, the CPSC staff has developed a model that allows them to estimate the number of ATVs in use; however these data are not representative of the number of participants. Without an accurate estimate of the number and types of participants in the activities, a risk comparison between and within them cannot be conducted with a reasonable level of confidence. Once a rate of risk can be calculated for each activity, investigators will be able to compare mitigation strategies within the activities to see which ones are effective. It is then possible to analyze which mitigation strategies that are effective in one activity, could possibly be translated to another to reduce the number of injuries or fatalities.
 - This would be a rather complex problem for the CPSC staff to solve. To obtain accurate participation estimate, the CPSC staff would need to develop a system and formula like the NEISS database uses to estimate the number of injuries in the nation.

6.3 Training

- Create and mandate a certified training program for ATVs.
 - According to the data gathered in this investigation, it is our opinion that mandating training with the sale of any new ATV will help to reduce the number of injuries. When investigating SCUBA diving and rock climbing, it was shown that there were a relatively low number of injuries and a high number of participants that had taken a training course. Mandating training with the sale of a new ATV will ensure that all new participants and some of the current participants receive a basic

training course from a certified instructor. This training should include: safe operation of an ATV (turning, types of terrain, etc.), use of safety gear, and handling of emergency situations. A certificate or card could be issued to identify participants who have taken the course. Keeping records of who has taken the course will also help the CPSC staff develop a better participation estimate for the activity. State agencies, such as the departments of motor vehicles or DMV, could store these records, giving the CPSC staff relatively easy access to them. It would have to be investigated if DMVs could afford to provide this service due to budget and manpower limitations.

- The major ATV manufacturers and participating ATV dealer currently offer a free course with the purchase of a new ATV. Although these courses are free of charge they are still not being attended. Mandating the training would make sure that everyone who purchases an ATV will receive proper training.
- Adopting a basic training curriculum into a voluntary standard, like SCUBA has done, may help ensure that the basic information is taught.
- Creating a certified ATV training program is very feasible. There are already various participant groups, such as the ATV Safety Institute, that have created safety courses that could be used as models.
- Recommend that participants in HARAs participate as groups utilizing the buddy system.
 - The buddy system has been used in SCUBA diving for a considerable time. Having someone there to help in case of an emergency is an invaluable resource. This could be included in the training courses offered by the different HARAs.

6.4 Safety Improvements

- Create an official, trail and climb rating system for ATV riders, rock climbers, and skiers.
 - While the current unofficial system for skiing has been adopted by every resort in the U.S., a new system with a greater level of definition could help skiers find the right trails for them with less need for experimenting. For example, an intermediate trail could be for someone just transitioning from beginner trails or someone almost ready for expert trails.
 - Unlike skiing, rock climbing has a variety of systems that are used throughout the US such as the Yosemite Decimal System (YDS) and the system used by the

- American Safe Climbers Association (ASCA). Combining these systems or making one the national standard would make finding a climb to fit one's skill level much easier.
- For ATV participants there is currently no system for defining the difficulty of a trail. Creating a national difficulty rating system for the trails would better educate participants about what terrain they must be able to navigate on a specific trail. Although this will not affect private land, this could prove to be effective in state and national parks and designated public riding areas.
 - This is a feasible but complex objective that can be investigated by the CPSC staff. It would require bringing together groups of professionals from the skiing, rock climbing, and ATV riding communities. The factors that contribute to the difficulty of each activity can be identified and categorized. The overall difficulty of each trail and climb can then be assessed based on what elements exist on a specific trail or climb.
- Create a voluntary standard for the minimum number of patrollers at ski resorts and create a trail patrol in national parks for climbers and ATV riders.
 - Ski patrollers are volunteers or employees of the resort who are the first responders to a medical emergency on the ski slopes. It is important to make sure that a specific ratio of patrollers to participants is maintained, in case of multiple emergencies.
 - Using the ski patrol model, create a network of patrollers for state and national parks to keep watch over climbers and ATV riders. The trail patrol could have the authority to enforce future ATV safety regulations and administer first aid to injured riders.
 - Another possibility would be to place a ledger at the entrance to ATV trails or climbing areas for participants to sign in. This list could be checked by a park ranger or volunteer to make sure that everyone who climbed has left at the end of the day. If a participant would want to stay more than one day, he or she would have to indicate so on the form.

- This will not protect participants from injury, but if someone were to injure themselves and were unable to get to medical assistance, then a ledger or travel plan of where they would be could save their life.
- Consider improvements to ski bindings or boots and or the development of a brace skiers can use to prevent knee sprains.
 - Knee sprains are the most common type of skiing injuries for which people visit hospital emergency rooms. Widespread use of a device that could reduce the number knee sprains could decrease the number hospital visits potentially by the thousands.

6.5 Future Projects

- Create a HARA database.
 - This project could be considered a proof of concept for comparing different activities to each other. It can be done and it can yield substantial results, but the process needs several refinements to increase the validity of its results. This can be done by standardizing the method used to compare activities. If a format could be developed that could be applied to all HARAs, then a database could be created. By using a database the information could be easily updated, comparisons between the activities made, and injury trends could be monitored.
 - This would be a challenge for the CPSC staff to create and maintain, but it is our opinion that they would find it helpful to have all relevant information on ATV riding to skateboarding in one convenient location.
- Conduct a behavioral analysis of the participants in risk-inherent activities such as the HARAs presented here.
 - Specifically, evaluate the influence the media has on the participants of the activity. Some HARAs have a large presence in the media; where professionals can be seen performing dangerous stunts, whereas other activities have very little or no media presence. No study to date has been done to determine what influence this has on the rate of injury for the activities, especially among younger viewers.
 - This could be easily accomplished through a human factors special study.
- Develop a universal model for determining and calculating risk involved in HARAs.

- If this database or calculator could be created, then the question of what is the level of risk for an activity can be answered. This could prove to be very valuable to the CPSC when justifying regulation for an activity. If a model could be made for activities, then it is possible that the concept could be applied to other consumer products as well.
- This would need to utilize all the databases currently utilized by the CPSC staff. The possible factors that could be included into the model are numerous; age, location, gender, use of safety equipment, cost of being injured.
- This would be a very complex project, requiring large amounts of time and money.
- Develop a project based on the injury cost model.
 - The goal of this project would be to reduce the number of injuries in HARAs by using the cost model to determine if injury mitigation strategies should be focused on common, low cost injuries, or on rare, high cost injuries.
 - This would be relatively easy for the CPSC staff to accomplish. There is already a method used by the Commission to calculate the cost of an injury, this would simply require using it to make comparisons between the types of injury within an activity.

Appendix A: Problem Statement

The mission of the U.S. Consumer Product Safety Commission (CPSC) is to protect the public from unreasonable risks of serious injury or death from more than 15,000 types of consumer products under the agency's jurisdiction. Deaths, injuries, and property damage from consumer product incidents cost the nation more than \$700 billion annually. The CPSC works to ensure the safety of consumer products - such as toys, cribs, power tools, cigarette lighters, and household chemicals (Overview, 2007).

One of the current focuses the CPSC staff is looking into is high adventure recreational activities (HARAs). Over the past few years they have noticed a dramatic increase in the number of participants as well as an increase in injuries. The fastest growing group in numbers of participants and injuries in these activities is children. The problem with the injuries that occur in HARAs is that they are viewed as isolated incidents and normally do not make front page news. This is because they kill only one or two at time, unlike major catastrophes such as the September 11th attacks. It is only through analyzing government reports and statistics that this increasing trend is coming to light and the true scope of the problem is being realized.

The importance of determining a way to minimize the risk to the participants cannot be understated. All Terrain Vehicles or ATVs are among the highest in the rate of injuries. Since 1982 the number of injuries has climbed from 10,100 to 136,700 in 2005, with approximately two to three hundred deaths per year (Safety Review, 2007).

There are many methods of risk management or mitigation options ranging from minor changes such as regulations and laws, to banning an activity completely. In between are options such as providing warning information, requiring redesign of the technology, etc. Our group will be helping the CPSC to analyze data about the risks involved in high adventure activities, such as: the number of people injured or killed, the cause of injury or death, the demographic of those involved, what types of injuries they suffered, and what factors contributed to the accident. We plan to develop a series of management approaches to address the problem. This is a broad spectrum of data that our group will need to filter and categorize. The refined data will be used to assess risk and reveal possible patterns between high adventure recreational activities.

Our team will utilize numerous types of resources. These will include the National Electronic Injury Surveillance System (NEISS) database, the CPSC In-Depth Investigation Database, news clip database, and hotline database. Outside of the CPSC our research will

include the Center for Disease Control (CDC), National Safety Council, the federal Register, manufacturers of equipment, and professional journals. In addition, interviews with representatives from academia, industry, and consumer groups will be conducted about the nature of the data, the activities, and the possible risk management options. Through research our group will develop a set list of criteria that will limit the number of high adventure recreational activities on which our group will be focusing.

Appendix B: Sponsor Description

The Consumer Product Safety Commission, or CPSC, was created by the Consumer Product Safety Act (15 U.S.C. 2051 *et seq.*), passed by Congress in 1972. The CPSC was created to protect the public "against unreasonable risks of injuries associated with consumer products" (CPSC Overview, 2007). The jurisdiction of the CPSC encompasses over 15,000 consumer products. The task performed by the CPSC has a large impact on society and the economy. For example, deaths, injuries and property damage from consumer product incidents cost the nation more than \$700 billion annually. The employees of the CPSC have done their job well, which is shown by the statistic that the CPSC is responsible for the 30% decline in the rate of deaths and injuries associated with consumer products over the past 30 years (CPSC Overview, 2007).

While the Commission oversees the safety of many consumer goods, it lacks the authority to regulate some products, including automobiles and other on-road vehicles, tires, boats, alcohol, tobacco, firearms, food, drugs, cosmetics, pesticides, and medical devices. It is a misconception that the CPSC staff tests consumer products before they are sold to the public.

In fact the Commission lacks the legal authority to test products before they are sold on the market (CPSC, 2007).

The CPSC is an Independent Federal Regulatory Agency that works to save lives and keep families safe by reducing the risk of injuries and deaths associated with consumer products by:

- developing voluntary standards with industry
- issuing and enforcing mandatory standards or banning consumer products if no feasible standard would adequately protect the public
- obtaining the recall of products or arranging for their repair
- conducting research on potential product hazards
- informing and educating consumers through the media, state and local governments, private organizations, and by responding to consumer inquiries (CPSC, 2007).

The CPSC endeavors to keep the public informed about product recalls and other important safety information through press releases to all the major media outlets and postings

on the CPSC website. The CPSC staff also makes available a variety of publications on consumer safety topics, which are free and in the public domain. Their website gives access to information concerning recalls and other product safety concerns.

The Commission is headed by 3 commissioners who are appointed by the President and confirmed by Congress. These commissioners are appointed for a term of seven years with no restriction as to how many times they can be reappointed. Commissioner Thomas H. Moore, is now in his second term. He was appointed by President Clinton in 1995. Mr. Moore; along with fellow Commissioner Ms. Nancy A. Nord who is the Acting Chairman, head the CPSC. The third commissioner position is currently vacant because President Bush has yet to nominate a person that can be approved by Congress. The Commission is headquartered in Bethesda, Maryland, with laboratories in Gaithersburg, Maryland, and regional offices in Chicago, New York, Kansas City, and Minneapolis. The CPSC currently employs about 420 people, of whom about 100 are CPSC investigators and compliance officers who are located in the various regional offices

The budget of the Commission is proposed by the President, which he gives to Congress for their approval. In 2007 and 2008 the President has requested the same amount of \$63,250,000 (CPSC, 2007). It is likely that he will gain approval, but due to the cost of inflation the Commission's budget is shrinking. *Table 5* provides a breakdown by category on what the CPSC spends its budget on.

2006 Budget

Reducing Product Hazards to Children and Families	FTEs	Amount (in millions)
Fire Deaths	142	21.44
Carbon Monoxide Poisoning	14	2.216
Children's and Other Hazards	167	25.931
Subtotal	323	49.587
Identifying Product Hazards		
Data Collection	80	11.361
Emerging Hazards/Data Utility	9	1.326
Subtotal	89	12.687
Total Commission	412	62.274

Table B-1: CPSC budget 2006

(CPSC, 2007)

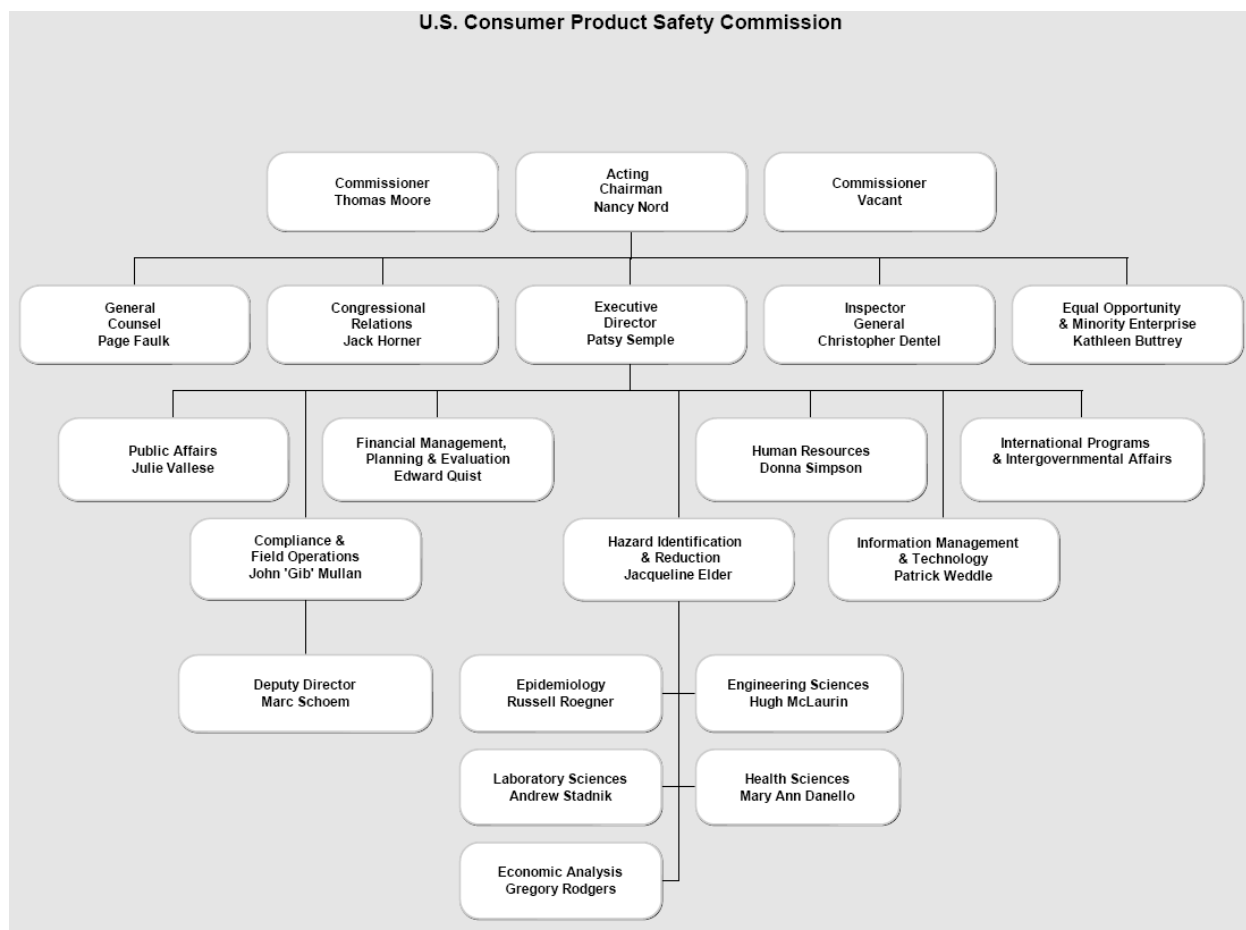


Figure B-1: U.S. Consumer Product Safety Organizational Chart (CPSC, 2007)

Appendix C: Tables and Charts

Reported ATV-Related Deaths of Children Younger Than 16 Years Old ATVs with 3, 4 or Unknown Number of Wheels January 1, 1982 to December 31, 2005

Year ³	Younger Than 16	Younger Than 16 Percent of Total
Total	2,178	30%
2005	120	26
2004	155	25
2003	152	24
2002	133	25
2001	132	26
2000	124	28
1999 ⁴	90	23
1998	82	33
1997	79	33
1996	87	35
1995	64	32
1994	54	27
1993	59	32
1992	71	32
1991	68	30
1990	81	35
1982-1989	627	40

Source: U.S. Consumer Product Safety Commission, Directorate for
Epidemiology, Division of Hazard Analysis.

Table C-1: ATV-related deaths of children

(CPSC, 2005)

Reported ATV-Related Deaths by Year
ATVs with 3, 4 or Unknown Number of Wheels
January 1, 1982 to December 31, 2005

Year ¹	Number of Deaths	Difference Since Last Update (12/31/2004)
Total	7,188	+694
<i>2005</i>	<i>467</i>	<i>+467</i>
<i>2004</i>	<i>609</i>	<i>+139</i>
<i>2003</i>	<i>636</i>	<i>+67</i>
<i>2002</i>	<i>540</i>	<i>+8</i>
<i>2001</i>	<i>517</i>	<i>+12</i>
<i>2000</i>	<i>451</i>	<i>+2</i>
<i>1999</i> ²	<i>398</i>	<i>-1</i>
1998	251	0
1997	241	0
1996	248	0
1995	200	0
1994	198	0
1993	183	0
1992	221	0
1991	230	0
1990	234	0
1989	230	0
1988	250	0
1987	264	0
1986	299	0
1985	251	0
1984	156	0
1983	85	0
1982	29	0

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, Division of Hazard Analysis.
 Italics denote the period for which reporting is incomplete.

Table C-2: Reported ATV-Related Deaths by Year

(CPSC, 2005)

**Estimated Number of Injuries And Risk of Injury
Associated with Four-Wheel ATVs
January 1, 1985 – December 31, 2005**

Year	Injury Estimate¹²	Estimated 4-Wheel ATVs in Use (millions)¹³	Risk Estimate per 10,000 4-Wheel ATVs in Use
2005	130,000	7.6	171.5
2004	129,500	6.9	187.9
2003	116,600	6.2	188.4
2002	104,800	5.5	190.0
2001	98,200	4.9	200.9
2000	82,300	4.2	197.2
1999	68,900	3.6	193.0
1998	57,100	3.1	184.7
1997	39,700	2.7	146.1
1996	40,700	2.4	168.1
1995	36,200	2.2	165.7
1994	33,300	2.0	165.4
1993	32,000	1.9	164.9
1992	33,000	1.9	175.1
1991	34,400	1.8	188.1
1990	30,800	1.8	175.1
1989	35,700	1.6	217.8
1988	39,400	1.4	276.1
1987	33,900	1.1	305.9
1986	23,400	0.7	319.2
1985	14,700	0.4	391.1

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, Division of Hazard Analysis; National Electronic Injury Surveillance System; and the Directorate for Economic Analysis.

Note: Coefficients of variation (CVs) for four-wheel ATV estimates for the years 1997 to 2005 range from 8.7 percent to 10.5 percent. CVs for estimates in column 3 of this table for the years 2001 to 2005 range from 3.2 percent to 3.8 percent. CVs for estimates in column 4 for the years 2001 to 2005 range from 9.3 percent to 10.0 percent (Levenson, 2005b and 2005c). CVs for years prior to 2001 for columns 3 and 4 are not available.

Table C-3: ATV-Related Injury Rates

(CPSC, 2005)

Reported ATV-Related Deaths by Year and Age Group
ATVs with 3, 4 or Unknown Number of Wheels
January 1, 1982 to December 31, 2005

Year¹⁵	Younger Than 12 Years Old	Younger Than 12 Years Old Percent of Total	Younger Than 16 Years Old	Younger Than 16 Years Old Percent of Total
Total	917	13%	2,178	30%
<i>2005</i>	<i>57</i>	<i>12</i>	<i>120</i>	<i>26</i>
<i>2004</i>	<i>59</i>	<i>10</i>	<i>155</i>	<i>25</i>
<i>2003</i>	<i>67</i>	<i>11</i>	<i>152</i>	<i>24</i>
<i>2002</i>	<i>45</i>	<i>8</i>	<i>133</i>	<i>25</i>
<i>2001</i>	<i>58</i>	<i>11</i>	<i>132</i>	<i>26</i>
<i>2000</i>	<i>50</i>	<i>11</i>	<i>124</i>	<i>27</i>
<i>1999¹⁶</i>	<i>34</i>	<i>9</i>	<i>90</i>	<i>23</i>
<i>1998</i>	<i>30</i>	<i>12</i>	<i>82</i>	<i>33</i>
<i>1997</i>	<i>38</i>	<i>16</i>	<i>79</i>	<i>33</i>
<i>1996</i>	<i>40</i>	<i>16</i>	<i>87</i>	<i>35</i>
<i>1995</i>	<i>26</i>	<i>13</i>	<i>64</i>	<i>32</i>
<i>1994</i>	<i>20</i>	<i>10</i>	<i>54</i>	<i>27</i>
<i>1993</i>	<i>18</i>	<i>10</i>	<i>59</i>	<i>32</i>
<i>1992</i>	<i>32</i>	<i>14</i>	<i>71</i>	<i>32</i>
<i>1991</i>	<i>40</i>	<i>17</i>	<i>68</i>	<i>30</i>
<i>1990</i>	<i>27</i>	<i>12</i>	<i>81</i>	<i>35</i>
<i>1982-1989</i>	<i>276</i>	<i>18</i>	<i>627</i>	<i>40</i>

Source: U.S. Consumer Product Safety Commission, Directorate for Epidemiology, Division of Hazard Analysis.
 Italics denote the period for which reporting is incomplete.

Table C-4: ATV-related deaths by age

(CPSC, 2005)

**Estimated U.S. Ski Industry Skier Visits by Region
1978/79 – 2006/07 (in millions)
(Extrapolated Data*)**

SEASON	Northeast	Southeast	Midwest	Rocky Mtn.	Pacific West	Total	Index (1978/79 = 100)
2006/07	11.801	4.888	7.200	20.849	10.330	55.068	110
2005/06	12.505	5.839	7.787	20.717	12.049	58.897	117
2004/05	13.681	5.504	7.533	19.606	10.579	56.882	113
2003/04	12.892	5.588	7.773	18.868	11.946	57.067	114
2002/03	13.991	5.833	8.129	18.728	10.913	57.594	115
2001/02	12.188	4.994	6.980	18.123	12.126	54.411	108
2000/01	13.697	5.458	7.580	19.324	11.278	57.337	114
1999/00	12.025	5.191	6.422	18.109	10.451	52.198	104
1998/99	12.299	4.261	6.005	18.440	11.084	52.089	104
1997/98	12.712	4.343	6.707	19.191	11.169	54.122	108
1996/97	12.407	4.231	7.137	18.904	9.841	52.520	105
1995/96	13.825	5.693	7.284	18.148	9.034	53.983	108
1994/95	11.265	4.748	6.907	18.412	11.346	52.677	105
1993/94	13.718	5.808	7.364	17.503	10.244	54.637	109
1992/93	13.217	4.660	6.978	18.602	10.575	54.032	108
1991/92	12.252	4.425	6.535	17.687	9.936	50.835	101
1990/91	11.157	4.257	6.486	16.706	8.115	46.722	93
1989/90	13.299	4.447	6.915	16.048	9.311	50.020	100
1988/89	12.741	5.424	7.013	16.601	11.556	53.335	106
1987/88	14.421	5.885	6.783	16.564	10.255	53.908	107
1986/87	14.745	5.816	6.944	16.680	9.564	53.749	107
1985/86	12.836	5.218	7.201	16.869	9.797	51.921	103
1984/85	11.083	4.394	6.899	17.626	11.352	51.354	102
1983/84	12.087	5.175	6.961	16.801	9.606	50.630	101
1982/83	9.523	4.256	6.213	14.808	12.061	46.861	93
1981/82	11.467	5.064	7.846	15.337	11.004	50.718	101
1980/81	8.953	4.172	7.668	10.466	8.401	39.700	79
1979/80	8.655	4.230	8.682	17.160	9.473	48.200	96
1978/79	11.294	3.763	9.743	15.837	9.560	50.197	100

Northeast: CT, MA, ME, NH, NY, VT, RI
Southeast: AL, GA, KY, MD, NC, NJ, PA, TN, VA, WV
Midwest: IA, IL, IN, MI, MN, MO, ND, NE, OH, SD, WI
Rocky Mountain: CO, ID, MT, NM, UT, WY
Pacific West: AK, AZ, CA, NV, OR, WA

* Users of the regional data in this table are cautioned that prior to 1982 no estimate of industry-wide skier visits was made for the "End of Season" studies. Therefore, for 1978/79 to 1980/81 the estimates were derived by applying the NSAA Members' Skier Visit Index. Since 1982, the estimates have been obtained by applying a statistical extrapolation procedure using regional mathematical equations derived from the NSAA survey respondent data. The procedure is reported in "An Estimate of the U.S. Ski Industry Business Volume and Lift Capacity for 1981/82," unpublished NSAA report (November 1982), by Marvin Kottke.

Table C-5: Estimated skier visits by region

(NSAA, 2007)

Appendix D: Interview Questions and Surveys

Participant Organization Questions

1. How many members are currently in the organization/association?
 - a. Can you describe the membership growth over the past decade?
2. Is there an age restriction for this organization/association?
 - a. If so, are there any additional requirements? (i.e.: safety gear variation b/t kids and adults)
 - b. [If children under the age of 16 can participate] What percent of children makes up the total number of participants?
3. What activities does the organization/association promote? (contests, tours, stunts, anything outside of the activity)
4. Does the organization/association provide training programs?
 - a. If so, what types of training programs are available? (first timers, advanced courses)
 - b. If not, what is the organization's position on training?
5. What are the most common types of injuries that occur?
 - a. What do you think contributes to these injuries?
 - b. What do participants do to minimize the risk of these injuries?
6. What safety measures does the organization/association promote? How (training, awareness, education/outreach)?
 - a. Are there any methods you could recommend to find a way to prevent/reduce these injuries?
7. Have you ever noticed participants voluntarily putting themselves in unsafe situations? Details? (not wearing safety gear, separating from group, etc)
 - a. Would you say the X-Games or Youtube plays a role in unsafe behavior?
 - b. What does the association/organization do to prevent this type of behavior?
8. In terms of comparing the risk involved in each activity, how would you rate your activity with [only one of: SCUBA diving/ATV riding/RC/skiing]? Why?
9. Would it be possible to send you a survey we have set up to get more information about the participants?
 - a. [If yes] Where can I send you the link for the survey?

Skiing Survey

Age _____

Sex (M/F) _____

1. How long have you been skiing? (Number of years) _____
2. Rate your level of skill on a scale of 1-10. 1=Beginner, 10=Expert _____
3. Rate the level of risk that you perceive is involved with the activity on a scale of 1-10. 1=Very Safe, 10=Very Risky _____
4. What types of skis do you use? (mark with an X those that apply)
 - a. Shaped _____, Twin Tips _____, Ski Blades _____, Telemark _____
5. How often do you ski? (mark with an X the one that applies)
 - a. Rarely _____, Occasionally _____, Weekly _____, Daily _____
6. How long do you ski for? (mark with an X the one that applies)
 - a. One Hour _____, Two Hours _____, Half Day _____, All Day _____
7. What type of skiing do you do? (mark with an X those that apply)
 - a. Slalom _____, Recreational _____, Half Pipe _____, Backcountry _____, Search and Rescue _____, Competitive _____
8. Do you wear a helmet when skiing?(Y/N) _____
 - a. In your own words, please explain in the space below why or why not.
9. Do you think the gear on the market today does a good enough job of protecting participants from injury? (Y/N) _____
 - a. If no, in your own words, please explain in the space below what could be improved or added.
10. Do you ever ski at night? (Y/N) _____
 - a. Do you do anything different when you do? (Y/N) _____
11. Have you ever attended a beginner training course? (Y/N) _____
12. Have you ever attended a more advanced or specialized training course? (Y/N) _____
13. (mark with an X the one that applies) Do you rent _____ or own _____ your own equipment or both _____?
14. (mark with an X the one that applies) How often do you do maintenance on your equipment?
 - a. Rarely _____, Occasionally _____, Weekly _____

- b. (mark with an X the one that applies) Do you do it yourself _____ or do you take it to a shop_____?
15. In your own words, please explain in the space below what you consider to be the risks involved with skiing.
- a. Do you think that allowing snowboarders and skiers on a mountain at the same time increases the risks? (Y/N) _____
16. Would you call yourself a safe skier?(Y/N) _____
17. Would you ever let your children ski? (Y/N) _____
- a. At what age? _____
- b. How do you think a child should be taught to ski?
18. Have you ever been injured because of skiing? (Y/N) _____
- a. Rate the injury on a scale of 1-10; 1=Minor, 10=Near death _____
- b. In your own words, please explain in the space below why you think it happened.
- c. Could this have been prevented with additional equipment or training?
19. Do you know someone who has been injured/killed from skiing? (Y/N) _____
- a. Rate the injury on a scale of 1-10; 1=Minor, 10=Near death _____
- b. In your own words, please explain in the space below what happened.
- c. Why do you think it happened?
20. Have you ever participated in ATV riding, SCUBA diving, or Rock climbing in addition to skiing? (mark with X on left if you have) How would you rank the following activities from 1 to 4 on the line to the right of the activity (1 being highest 4 being lowest risk)?

<u>Activities Participated in</u>	<u>Level of risk</u>
_____ ATV _____	
_____ SCUBA _____	
_____ Rock climbing _____	
_____ X _____ Skiing _____	

All-Terrain Vehicle Survey

Age _____ Sex (M/F) _____

1. How long have you been riding ATVs? (number of years) _____
2. What type of ATV do you ride? (mark with an X those that apply)
 - a. Three-wheeler _____, Four-wheeler _____, More than four wheels _____
3. What size engine does your ATV have? (mark with an X the one that applies)
 - b. 30-90cc _____, 100-200cc _____, 250cc or more _____
4. How often do you ride? (mark with an X the one that applies)
 - c. Rarely _____, Occasionally _____, Weekly _____, Daily _____
5. Where do you normally ride? (mark with an X those that apply)
 - d. Track _____, Marked Trails _____, Rugged areas with no trails _____, Dirt roads _____, Paved roads _____
6. What gear do you wear while riding? (mark with an X those that apply)
 - e. Helmet _____, Boots _____, Gloves _____, Goggles _____, Chest Padding _____
 - f. Do you think the gear on the market today does a good enough job of protecting participants from injury?(Y/N) _____
7. Have you ever raced?(Y/N) _____
8. Do you ever ride at night?(Y/N) _____
 - g. Do you do anything different when you do?(Y/N) _____
 - h. In your own words, please explain in the space below why.
9. Have you ever attended a training course? (Y/N) _____
 - i. What type of certification did you receive?
10. How often do you do maintenance on your equipment? (mark with an X the one that applies)
 - j. Rarely _____, Occasionally _____, Weekly _____, Daily _____
 - k. Do you perform maintenance yourself or do you take it to a shop?
11. Do you ever ride with passengers on the back?(Y/N) _____
12. In your own words, please explain in the space below what you consider to be the risks involved with ATVs.
13. Would you call yourself a safe driver while operating an ATV? (Y/N) _____

14. Would you ever let your children drive an ATV? (Y/N) _____

l. At what age? _____

m. In your own words, please explain in the space below how a should child be taught to ride an ATV.

15. Do you think the media has changed many people's opinions of the sport in a good or bad way?(Y/N) _____

16. Have you ever participated in SCUBA Diving, Rock climbing, or Skiing in addition to ATV riding? (mark with an X on left if you have) How would you rank the following activities from 1 to 4 on the line to the right of the activity (1 being highest risk and 4 being lowest risk)?

<u>Activities Participated in</u>	<u>Level of risk</u>
_____ SCUBA _____	
_____ Rock climbing _____	
_____ Skiing _____	
_____ X _____ ATV Riding _____	

Rock Climbing Survey

Age _____ Sex (M/F) _____

1. How long have you been rock climbing? (Number of years) _____
2. (mark with an X the one that applies) How often do you climb?
 - a. Rarely _____, Occasionally _____, Weekly _____, Daily _____
 - b. (mark with an X the one that applies) How long do you climb for?
 - i. Hour _____, Few Hours _____, Half Day _____, Full Day _____
3. (mark with an X the one that applies) Where do you normally climb?
 - a. Outdoors _____ Indoors _____
4. Have you ever climbed competitively? (Y/N) _____
5. What type of climbing do you do? (Mark ones that apply with X)
 - a. Bouldering _____, Rappelling _____, TRAD climbing _____, Free climbing _____
6. What gear do you use while climbing? (mark ones that apply with X)
 - a. Helmet _____, Harness _____, Ropes _____, Cams _____
 - b. Do you think the gear on the market today does a good enough job of protecting participants from injury?(Y/N) _____
7. Have you ever attended a safety course? (Y/N) _____
 - a. If no, how did you learn the activity?
 - i. Self-taught _____, Mentor _____, Other _____
8. (mark with an X the one that applies) How often do you check your equipment for signs of wear, tears in the fabric, etc.?
 - a. Rarely _____, Occasionally _____, Weekly _____, Before every climb _____, After every climb _____
9. Do you always climb with a partner?(Y/N) _____
10. In your own words, please explain in the space below what you consider to be the risks involved with climbing.
11. Would you call yourself a safe climber?(Y/N) _____
12. Would you ever let your children rock climb?(Y/N) _____
 - a. At what age? _____

b. In your own words, please explain in the space below what you think is the best way for children to learn how to climb.

13. Do you think the media has had an effect on the public view of climbing?(Y/N)_____

14. Have you ever participated in ATV riding, SCUBA diving, or Skiing in addition to rock climbing? (mark with X on left if you have) How would you rank the following activities from 1 to 4 on the line to the right of the activity (1 being highest 4 being lowest risk)?

<u>Activities Participated in</u>	<u>Level of risk</u>
_____ATV_____	_____
_____SCUBA_____	_____
_____Skiing_____	_____
_____X_____Rock Climbing_____	_____

SCUBA Diving Survey

Age _____

Sex (M/F) _____

1. How long have you been scuba diving? (Number of years) _____
2. (mark with an X those that apply) Do you normally dive in fresh _____ or salt water _____?
3. (mark with an X those that apply) How often do you dive?
 - a. Rarely _____, Occasionally _____, Weekly _____, Daily _____
4. (mark with an X those that apply) What gear do you use while diving?
 - b. Weight belt _____, Mask _____, Snorkel _____, Wet Suit _____, BC _____, Fins with boots _____, Dive Computer _____, Compass _____, Pressure Gauge _____, Octo _____, Light _____, Extra _____ (if so list)

 - c. If some equipment not used, please explain why in the space below.
5. What certifications do you have? (mark with an X those that apply)
 - d. Basic _____, Advanced _____, Night _____, Wreck _____, Cave _____, Instructor _____, Search and Rescue _____, Commercial _____, Dive Master _____
 - e. Extra: _____
6. Rate your level of skill on a scale of 1-10. 1=Beginner, 10=Expert _____
7. Rate the level of risk that you perceive is involved with the activity on a scale of 1-10. 1=Very Safe, 10=Very Risky _____
8. In your own words, please describe in the space below what you consider to be the risks involved with scuba diving?

9. (mark with an X those that apply) Do you rent _____ or own _____ your own equipment or both _____?
10. (mark with an X the one that applies) On the equipment you own, how often do you perform maintenance?
 - f. Rarely _____, Occasionally _____, Weekly _____
 - g. Do you follow the regulations regarding VIP and hydro tank testing?(Y/N) _____
11. Have you ever gone diving without a partner?(Y/N) _____
12. Would you let your children scuba dive? (Y/N) _____

- h. At what age? _____
- i. How should a child be taught to SCUBA dive? _____
- 13. Have you ever been injured because of diving? (Y/N) _____
- j. Rate the injury on a scale of 1-10; 1=Minor, 10=Near death _____
- k. In your own words, please explain in the space below why you think it happened.
- l. In your own words, please explain in the space below if this could have been prevented with additional equipment or training.
- m. Do you know someone who has been injured/killed from diving? (Y/N) _____
- n. Rate the injury on a scale of 1-10; 1=Minor, 10=Near death _____
- o. In your own words, please explain in the space below what happened.
- p. In your own words, please explain in the space below why you think it happened

14. Have you ever participated in ATV riding, Rock climbing, or Skiing in addition to SCUBA diving? (mark with X on left if you have) How would you rank the following activities from 1 to 4 on the line to the right of the activity (1 being highest risk and 4 being lowest risk)?

<u>Activities Participated in</u>	<u>Level of risk</u>
_____ ATV _____	
_____ Rock climbing _____	
_____ Skiing _____	
_____ X _____ SCUBA diving _____	

Appendix E: Interview Minutes

All-Terrain Vehicle Association

WPI representative: Neal Rosenthal

ATVA representative: Mr. Doug Morris

General Information

- Exclusively ATVA: 9000+
- ATVA is a division of AMA, which has ~290,000
- Growth over the years depends on sales; but overall, constant
- Recreational riding: any age is allowed
- Competition riding: there is an age restriction
 - In addition, ATV must meet ATVA standards
- Only do recreational and competition riding
- No training; strictly membership organization
 - Highly stress safety
 - Recommend ASI for training program
- Most companies promote free training with the purchase of an ATV
- Dealers are making consumers aware of free training with huge amount of safety awareness and incentive of taking training

Issue Safety and Behavior of Participants

- Anything can happen in a competition, but most people drive very responsibly in recreational riding
- Considers an ATV exceptionally stable
- People don't take training course; think they can just ride an ATV without difficulty
- Advice: always ride with someone, ride appropriately, don't carry passengers, don't drink and drive, wear safety gear
- Suggestion: state law and enforcement
 - Eg: seatbelts (there is a law, but people still don't wear them)
 - Consider monetary/jail time consequences
- People should always drive on the trails
- **Proper supervision over inexperienced riders** (huge emphasis)
 - ATVs require a key, so where are the parents?
- Suggestion: get the training, it makes a BIG difference
 - Mentions a study in Utah showing the efficiency of training
- Suggestion: educational program in grade school on safety
 - There are bike safety campaigns, but not youth ATV campaigns
- Opinions on Youtube/X-Games: "Pretty well a fact"; people want to copy what they see
 - Children growing up seeing extreme activities
 - Children are very impressionable, thoughts and actions based on environment
 - Eg: take a Chinese baby, bring him to the south, and he'll have a southern accent
- Articles on safety: "Safety First"
 - Find a serious injury/fatality and analyze the faults

- In situations where helmets are not required, they are strongly recommended
- Opinion on ATV vs rock climbing: people might see ATVs as easier/simpler but not necessarily less risky

American Mountain Guide Association

WPI representative: Neal Rosenthal

AMGA representative: Mr. Justin Yates

General Information

- ~1300 people
- Age restriction of 18 years old
- Three types of climbs available
 - Rock, alpine, and ski
 - Training and certification available for each
- Other introductory courses
 - Top rope site manager (phased out)
 - Replaced with single pitch instructor (climbing single pitch)
 - Covers leading

Issue of Safety and Behavior of Participants

- Code of Ethics available
- Talking to other people helps prevent injury

Other comments: felt he did not have the justification to comment on several questions

Fox Valley All-Terrain Vehicle Association

WPI representative: Neal Rosenthal

FVATVA representative: Mr. Scott Siebert

General Information

- Composed of 10 (ten) people
 - Created in 1987
 - Highest number of people: 50-60
- Always adults
- Meeting once a year to retain status of non-profit association
- No training; people are already experienced

Issue of Safety and Behavior of Participants

- Cannot comment on injury types; no injuries in three years
- Suggest helmets, riding gear, and safe riding
- Suggestion: don't drink and ride
- Haven't noticed people putting themselves in unsafe situations
- Views SCUBA as more dangerous than ATV

Los Angeles Council

WPI representative: Neal Rosenthal

LAC representative: Ms. Judith Miller

General Information

- One of the 10 councils in the Far West Council
- Must be 21 (drinking age)
 - The executive board is all juveniles
 - Some clubs have family memberships
- Does summer volleyball, Man/Woman of the Year, “Ski Week”, trip to Costa Rica
 - Each council does something different
- Meetings to talk about trip insurance programs, showing of new equipment (eg: helmets)
- Does not do training, but advertise to a certain person
 - Doesn’t have adequate funding
- Have access to helmets and are sold with benefits
 - Instructor’s responsibility

Issue of Safety and Behavior of Participants

- Injuries occur when taking off
 - Head and back injuries
- Short skis can cause knee injuries
- Head injuries have been reduced with helmets
 - Strongly urge skiers to wear helmets
 - 80% of Mammoth Hill skiers have helmets
- Snowboarders don’t pay attention; not allowed on course
- Skiers should wear protective/good equipment, have good instruction, don’t ski beyond ability (peer pressure as an example), physical condition (dress warm)
- Suggestion: NC, except be a strong skier
- Risks include skiing outside of boundaries
 - May not necessarily be people putting themselves in unsafe situations
- In general, risk in SCUBA > skiing

National Association of Underwater Instructors

WPI representative: Neal Rosenthal

NAUI representative: Mr. Randy Botteri

General Information

- Children can participate; as young as 10 years old
- NAUI promotes aquatic activities and sponsored cleanups
- Wide variety of training available (instructor, dive master, technical, etc)
 - Other types of training are not listed on the website; based on popularity

Issue Safety and Behavior of Participants

- Injuries rarely occur; no “common” type of injury
- Recommendation: all based on education
- Injuries occur due to lack of education
- No true comparison between SCUBA and Skiing

North West Ski Club Council

WPI representative: Neal Rosenthal

NWSCC representative: Ms. Mary Olhousen

General Information

- About 10,000 people
 - Compilation of clubs in Oregon, Washington, Idaho
- Some clubs accept children, but 98% of them have an age restriction of 21+
- All clubs hold activities all year, including hiking, biking, golf, picnics
- Does not have a training routine for first timers

Issue Safety and Behavior of Participants

- Articles in newsletters, in person presentation, ski industry buys into supporting safety contests
- Many of the participants comply with the safety issues addressed
- Always inherent risk involved
 - Skiing out of control
- Suggestion: more campaigns for awareness
- In general, risk for SCUBA > skiing

Ohio Council of Skin and SCUBA Diving Inc.

WPI representative: Neal Rosenthal

OCSSDI representative: Mr. Donald Snyder

General Information

- About 300 members
- Composed of Ohio clubs
- Associate membership
- No age restriction, but standard certification requires at least an age of 12 years old
- 16 year old can be a junior diver and must dive with an instructor
- Money is raised through scholarship funds
- License plates
- Coastal cleanups
- Occasional meetings
- Attempting to get legislation of O₂ to ease process of access
 - Helps deal with bends
- Does not offer training, but promotes training and safe diving
 - Relies on other organizations to issue certification
- Don't dive year round, but ice diving is available

Issue of Safety and Behavior of Participants

- Most common injury is barotrauma due to poor equalizing the ears
 - Not following the rules and pushing their limits
- Safe sport with inherent risk; “kids will be kids”
- Self regulating activity (no police)
- Gear-intense sport
- Training greatly reduces chance of injury
- Legislation within the OCSSDI
 - Dive Flag Law
 - It has been around for a long time; they are trying to educate boaters
 - Shipwreck and Salvage Law
- Suggestion: you can only do so much; it just doesn't work to an extent
 - Eg: people refuse to wear seatbelts, passing more laws won't have much of an effect
- Media coverage (like Youtube) can be responsible for people putting themselves in unsafe situations
- Because groups are so small, they are more open to discussions and warnings
 - In some cases, they will resort to the owner
 - Helps prevent injuries among the groups
- SCUBA vs rock climbing: unsure; both are equipment intense, require maintenance, and paying attention to the rules

Southern California Mountaineers Association

WPI representative: Neal Rosenthal

SCMA representative: Ms. Yvonne Tsai

General Information

- Contact: Board of Director/Membership Chair
- 200+ members
- 18+ age requirement
- Various types of climbs (eg: mountaineering, aid climbing, exploration/trekking); varies with difficulty
- Also have picnics
- Volunteer work
- Screen members to ensure their safety skills before allowing them to climb
- Only 1 scheduled course a year
 - Novice Training Course (NTC)
 - Takes several months to complete
 - Each session is a whole day, on Saturday
 - Must attend each session; money commitment
 - Lots of variety
 - Must pass exam within the year to pass the NTC
 - NTC covers rescue, knots, and other basic skills to avoid dangerous situation

Issue of Safety and Behavior of Participants

- Injuries commonly occur during repelling
 - Mercy of the rope
- Injuries also occur when a leader leaves his stand
 - Similar to soloing a climb
- Injuries also occur during a pendulum fall
 - Losing your footing
- Minimizing risk: be “in the moment”
 - Be aware of what you are doing; think of the consequences
 - People forget to check equipment before repelling and can fall
 - RC is NOT forgiving; a mistake can cost you your life.
- There is a safety committee that monitors unsafe behaviors; “watch dogs”
- Recommendation: Outside of being very mindful of your actions, NC
- People rarely put themselves in unsafe situations
 - Safety is stressed
- NC on X-Games/Youtube
- Opinion of RC vs ATV: NC, but aware of ATV riders getting hurt
 - As long as you get training, you are safe
 - Inherent risk

Vermont ATV Sports Association

WPI representative: Neal Rosenthal

VASA representative: Mr. Dan Hale

General Information

- About 1900 people
- Age restriction of 18 years old
- Trail organization and fundraising
- Does not provide a training routine
- Code of Ethics available; guidelines published
- Safety course available for those under 18 years old
- Manufacturers provide safety information

Issue Safety and Behavior of Participants

- Always have to adjust in uncommon driving situations
- If you adhere to the rules, you won't get hurt
- Injuries caused due to lack of gear or attention to guidelines
- Suggestion: reinforce safety information, equipment, technology; not understanding your actions will result into consequences
- Considers SCUBA no more risky than ATV
 - SCUBA is not risky if done correctly
 - Other activities might be more dangerous due to more elements involved
 - Based on the person's ability

Voluntary Standards

WPI representative: Neal Rosenthal

CPSC Representative: Colin Church

- If desirable to make a voluntary standard (VS), write letter to standards coordinating organization (ANSI, ASTM, UL)
 - Provide death/injury data, organizations who would be interested
 - ANSI/ASTM do not write own standards
 - UL writes their own standards
 - Each standards coordinating org (SCO) has its own procedures
 - National consensus standards: opportunity for all parties to be involved
 - Effective/timely standards with openness, interest, and process
 - ASTM has never rejected a request for a VS
 - To determine what needs to be done to implement VS: Analysis of injury/death data, labeling remedies, testing methods
 - Will hold meetings, draft standards, send to SCO (60% return), second validating process (90% must approve)
 - Process every 5 years to review VS
 - VS are published and sold by SCOs
- Types of VS issued by (within CPSC only):
 - ASTM: children/juvenile products
 - UL: electronic products
 - ANSI: scattered around in different areas
 - Not bound within respective SCO
 - Covers 90%+ of the VS issues
- Advantages of VS over Mandatory Standard (MS)
 - “It’s the law”
 - Required to use VS
 - They must meet two standards
 - Must effectively reduce hazard
 - Needs to be used
 - Government perspective
 - National Technology Transfer and Advancement Act: all government entities will work with VS or explain why VS were not used
 - Money wise
 - VS save money
 - Commission only pays technical support (small %)
 - MS: Commission must pay entire cost (laboratory use, testing, etc)
 - Also time efficient (faster)
 - MS require review, justification, cost-benefit analysis, etc
- Notice of Proposed Regulation (NPR)
 - Attempts to capture interest of those involved
 - Providing notice to the public
 - Also an advanced NPR: information gathering tool

- Next step: noticed of proposed rulemaking
 - Commission will then decide what it wants to do
 - VS::MS 10 to 1 ratio
 - 2007: provided tech support to 72 VS
- Reasons people don't pay attention to VS
 - Costs time to send people to meetings
 - "It's voluntary, why do I have to worry about it?"
 - VS are adapted as law by the state
 - If there is a big problem with a product, it can be treated as a MS/take immediate action
 - Fact: people can go to court and be charged due to lack of knowledge of VS
- In fiscal year 2007: provided support to help create 38 new VS
- Go online (cpsc.gov → performance and accountability report)
 - Found on the homepage
 - More details available in that PDF

Compliance

WPI representative: Patrick Goodrich

CPSC representative: Tanya Topka

- What compliance does
 - Recalls
 - If product is found to be defective a recall is called by CPSC
 - Manage ATV program
 - Fill out voluntary action plans with manufacturers
- Section 15
 - Can conduct corrective action
 - CPSC states how a problem should be fixed
 - Then a recall alert is sent
 - For candles
 - Reported problems will be tested by CPSC
 - When they find them to be faulty a recall is started
- Regulation/Rule
 - This is required legislation that all manufacturers must follow
- Once a driver gets on the road chance of death jumps
 - Death, not injury
- Most of the measures in effect are to increase safety
 - Reduces the chances of some injury
- Introduction of ATV tank like treds have helped
 - Used a lot in Alaska
- When talking to companies
 - Normally talk to attorneys and other legal representatives
 - Talk to a lot of product safety organizations
 - Work together a lot
 - Most organizations have inside legal council, but some employ outside council
- Size of compliance
 - 30 or so officers in house
 - 75-80 in the field
 - Kept very busy
 - Jacks of all trades
 - Some specialize for a product, but the majority do everything
 - Many different educational backgrounds
 - In house
 - Mostly political science and public relations
 - Majority learn through the job
 - Not specialized when entering the CPSC

Related Investigations

WPI representative: Maxwell LaFrance

Principle Investigator of *Risky Business*: Dr. Kirk Astroth

- Originally taught high school in Tucson, Arizona
 - Students were members of 4-H, first knowledge of the program
- Was suggested to work for the 4-H by career advisors in 1983
- Has been at the University of Montana since 1990
- National 4-H approached him with a research project
 - Wanted to learn if there was anything in other fields that could help reduce injuries in risk inherent leisure activities
 - Could ATV safety adopt something from another activity?
- Research focus on already published academic findings
 - Did not do any original research
- Worked with Jeff Lincolnback, an expert on social norms
 - Author, professor at Hobart Smith College in NY
- Is currently drafting a research proposal to the 4-H and SVIA
 - Have teams of researchers and 4-H youth observe ATV trail heads
 - Record the behavior of riders, speed, carrying passengers, etc.
 - Hopefully in May-July 2008

Appendix F: Map of NEISS Hospitals

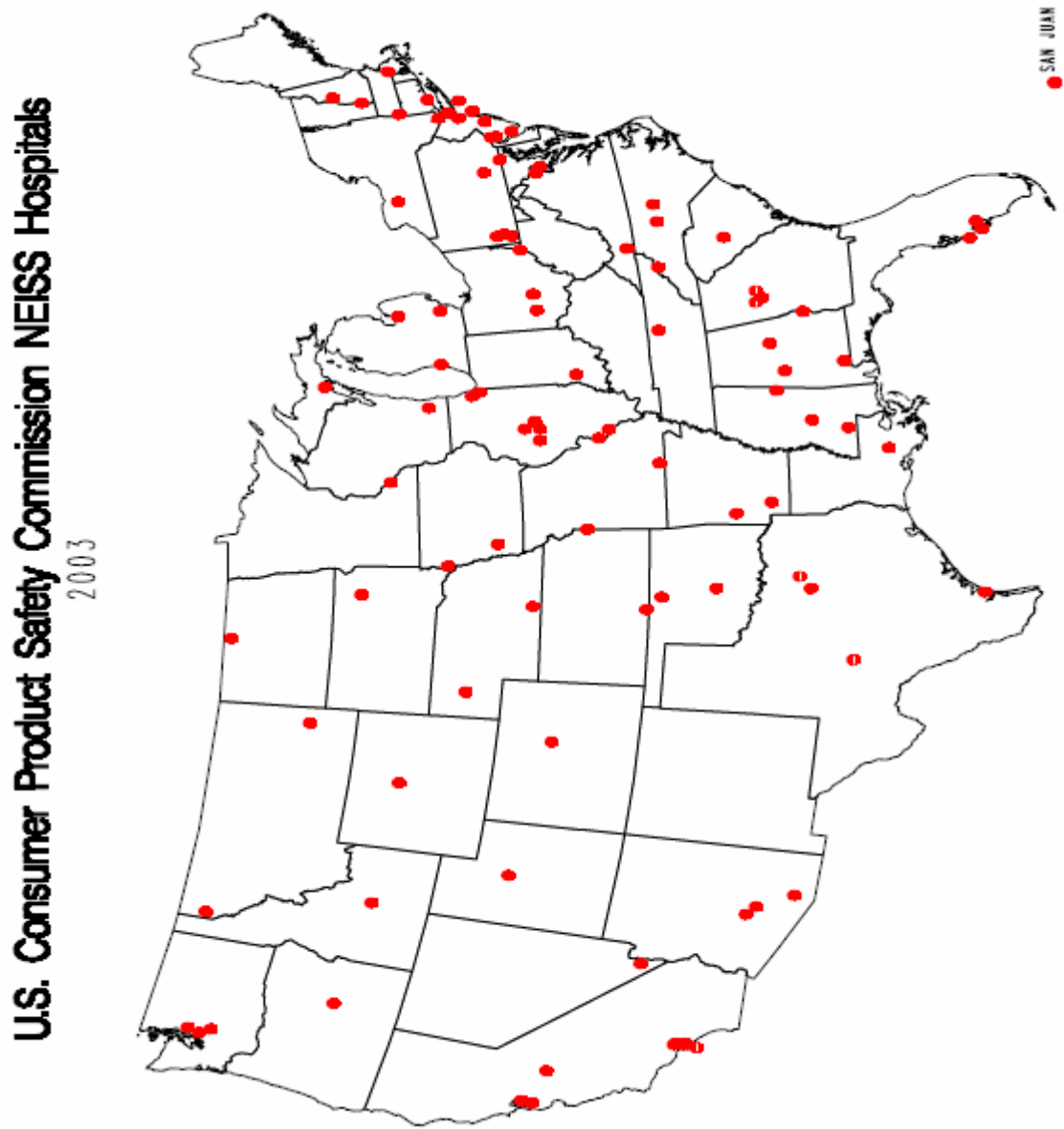


Figure F-1: Map of NEISS Hospitals as of 2003

(CPSC, 2007)

Appendix G: Equations

- **Equation 1: Coefficient of Variance (NEISS):**

Estimate \pm (1.96 * Estimate* CV) = (Estimate Upper Bound, Estimate Lower Bound)

- This is the equation that was used by our group to determine the upper and lower error boundaries of the estimates generated by the NEISS database.

Appendix H: Supplementary Data

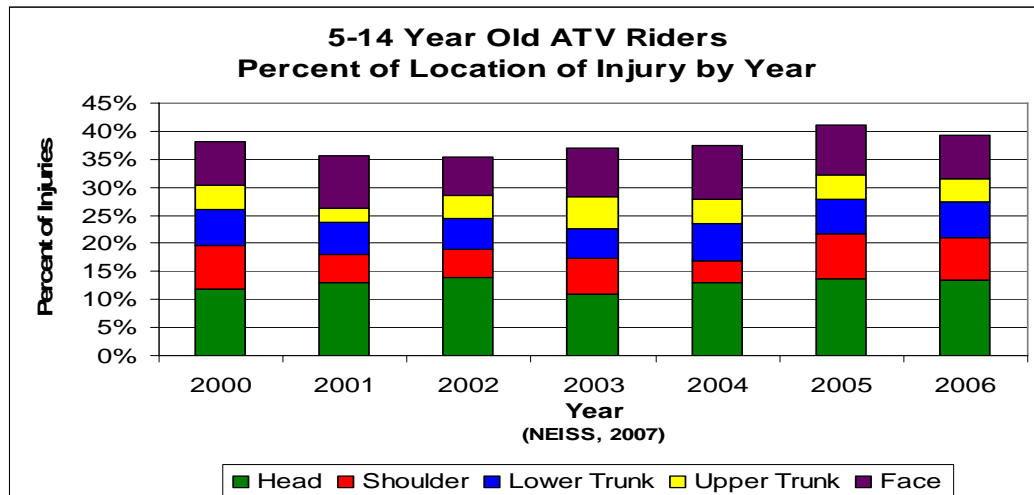


Figure H-1: 5-14 Year Old ATV Riders, Percent of Location of Injury by Year

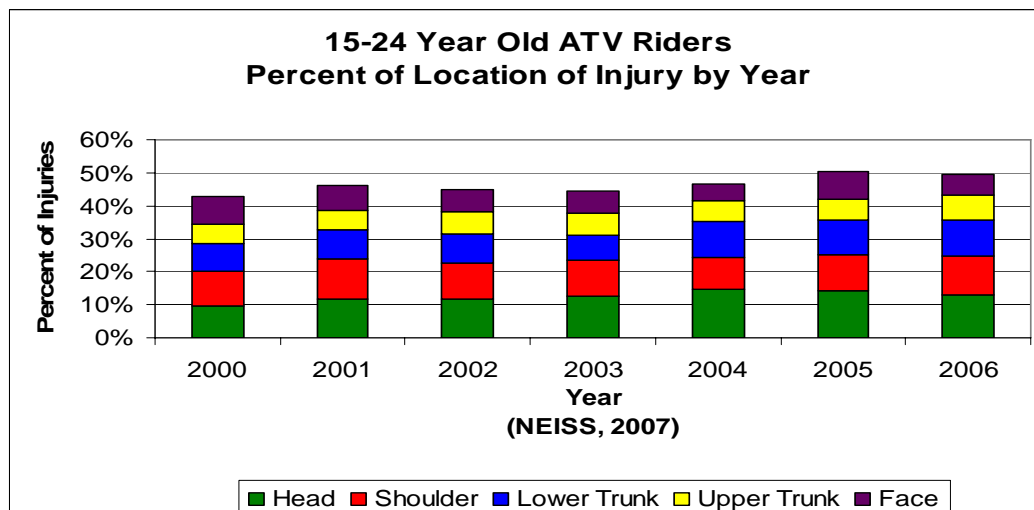


Figure H-2: 15-24 Year Old ATV Riders, Percent of Location of Injury by Year

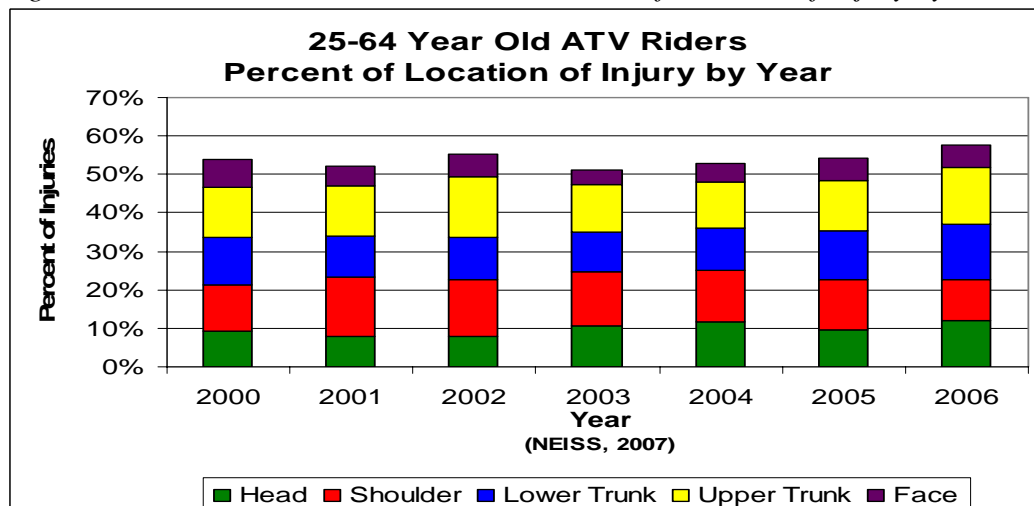


Figure H-3: 25-64 Year Old ATV Riders, Percent of Location of Injury by Year

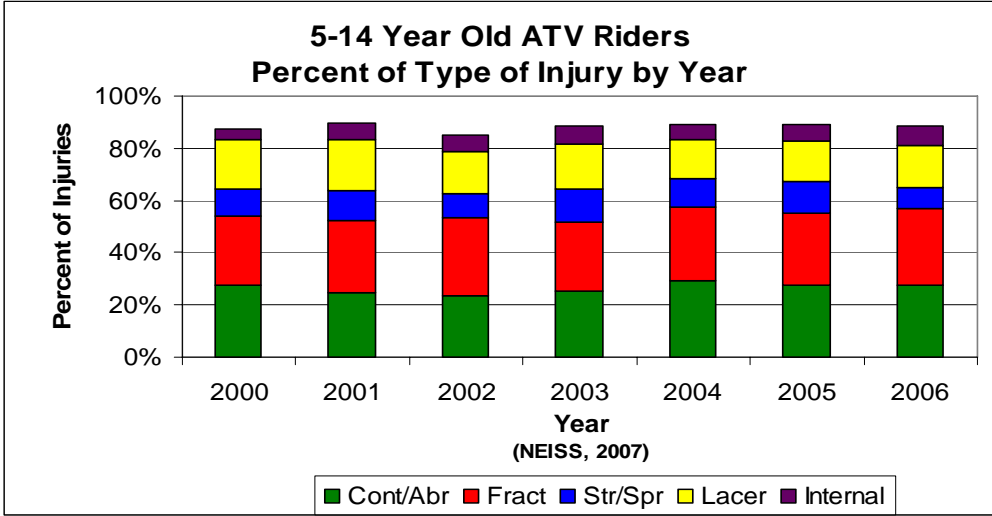


Figure H-4: 5-14 Year Old ATV Riders, Percent of Type of Injury by Year

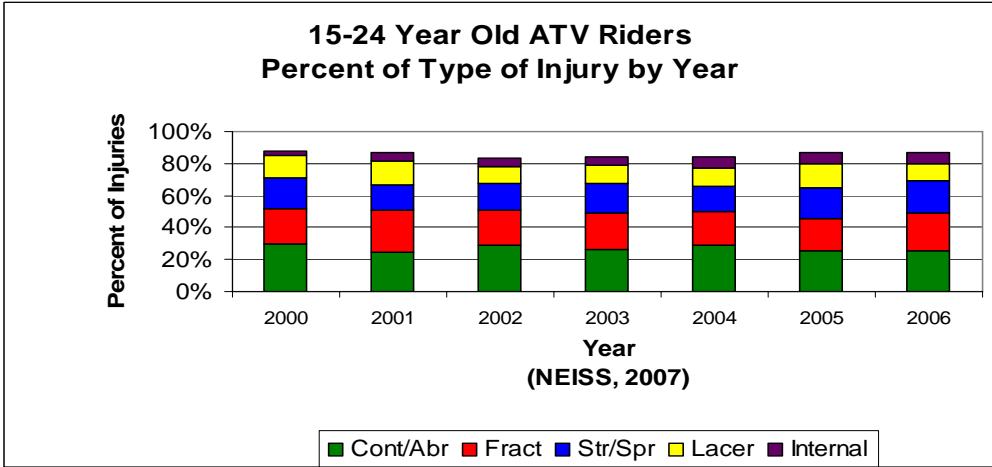


Figure H-5: 15-24 Year Old ATV Riders, Percent of Type of Injury by Year

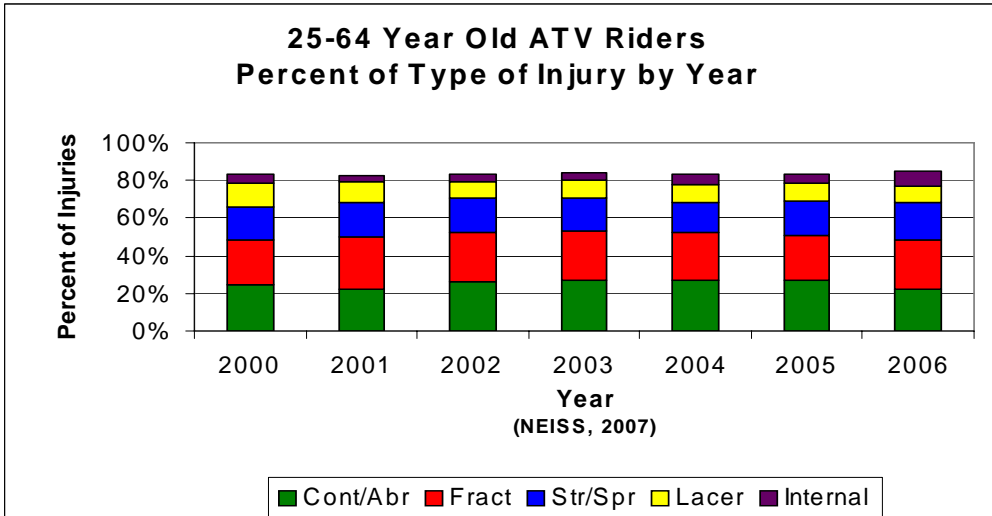


Figure H-6: 25-64 Year Old ATV Riders, Percent of Type of Injury by Year

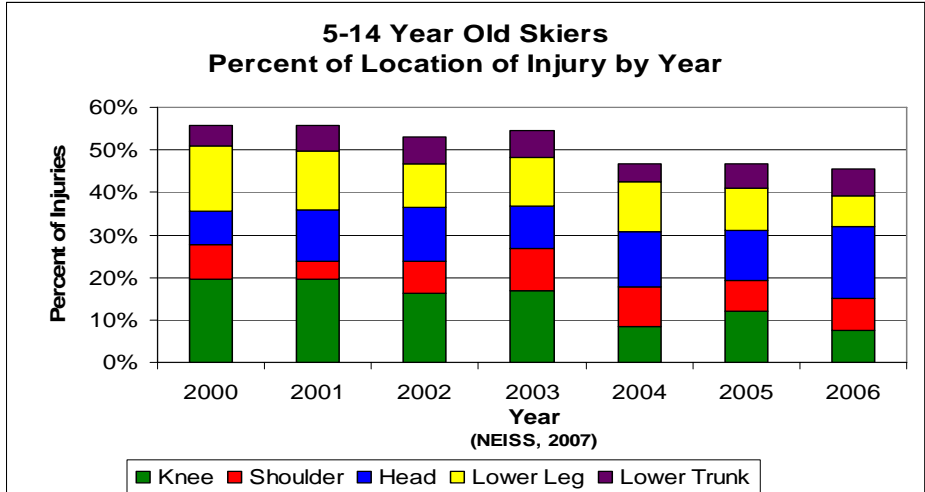


Figure H-7: 5-14 Year Old Skiers; Percent of Location of Injury by Year

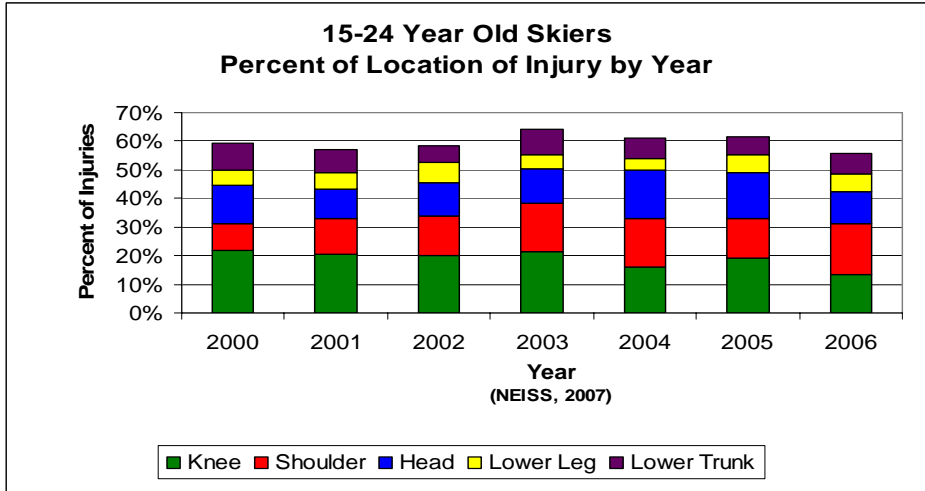


Figure H-8: 15-24 Year Old Skiers; Percent of Location of Injury by Year

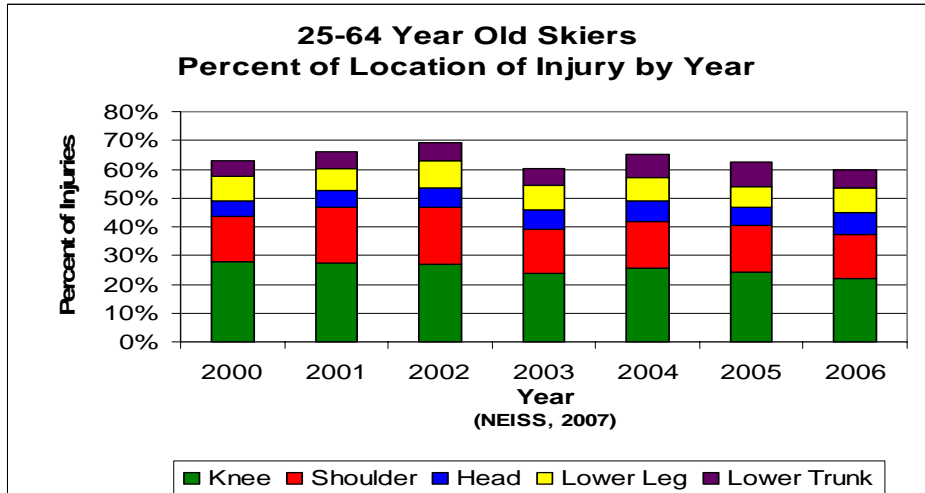


Figure H-9: 25-64 Year Old Skiers; Percent of Location of Injury by Year

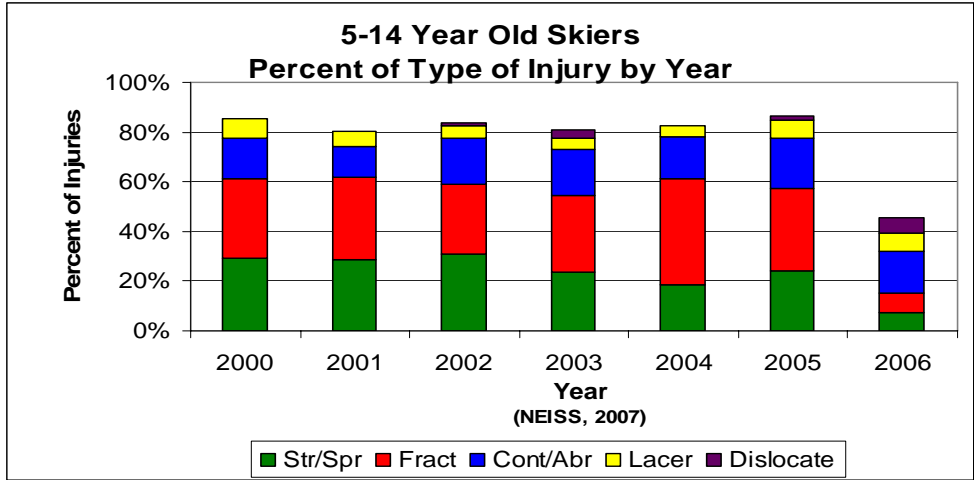


Figure H-10: 5-14 Year Old Skiers; Percent of Type of Injury by Year

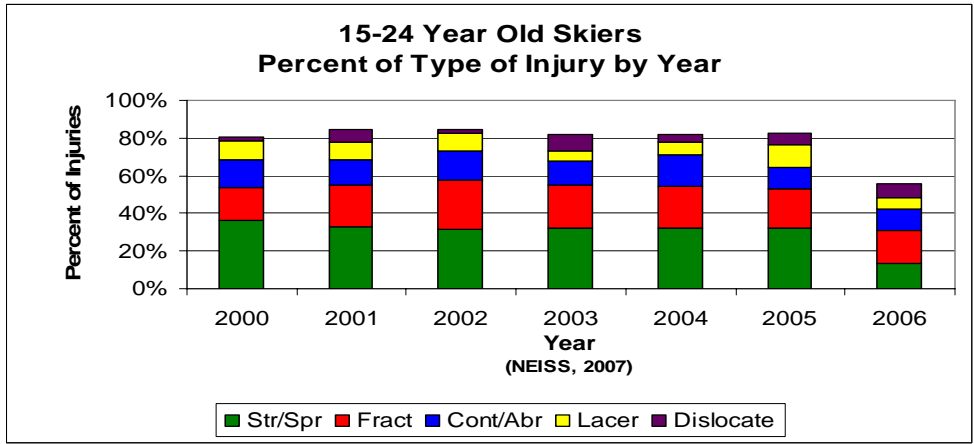


Figure H-11: 15-24 Year Old Skiers; Percent of Type of Injury by Year

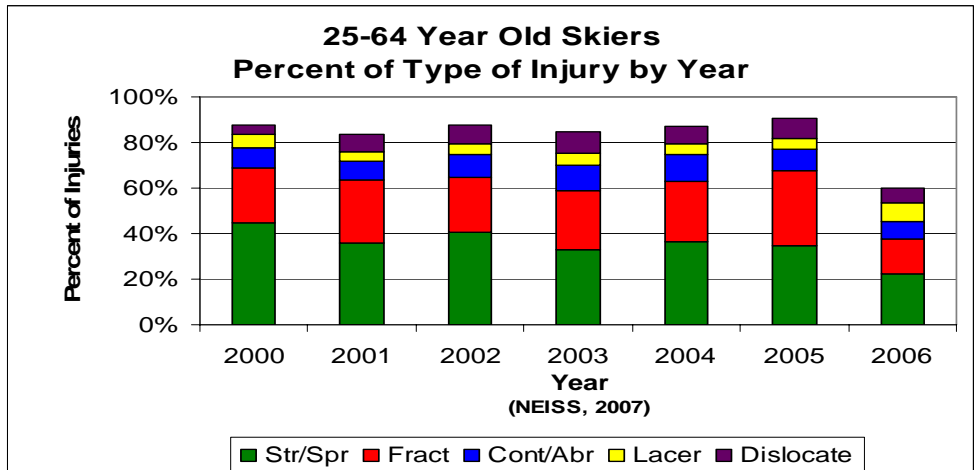


Figure H-12: 25-64 Year Old Skiers; Percent of Type of Injury by Year

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