SNOW IMMERSION SUFFOCATION- THE SILENT KILLER AT SKI AREAS

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ABSTRACT:
From 1990/91 to 2011/12, there have been sixty-four Snow Immersion Suffocation (SIS) cases reported at U.S. ski areas. Comparing inherent risks at ski areas during the same period, there have been sixty avalanche fatalities resulting from ticketed skiers leaving the designated ski area boundary (out of bounds) and nine avalanche fatalities that have occurred within ski area boundary (in bounds). The risk to in bounds skiers and snowboarders of snow immersion suffocation is six times greater than the risk of avalanches.
With an average of just over four SIS fatalities each ski season in the last ten years and accounting for an average of ten percent of all ski area accidental deaths on an annual basis it has become one of he most significant inherent risks in the sport of alpine skiing and snowboarding. Recent progress has been made in the development of educational awareness and prevention strategies and tools.
This risk trend appears to be “under the radar’ of much of the skiing and snowboarding public and even many snow safety professionals. However good progress has been made in the development of educational awareness and prevention tools for both the skiing public and the snow professional.
This study was designed to compare the risk trends of in bounds and out of bounds avalanche fatalities with snow immersion events, to analyze the SIS case data from 1990/91 to 2011/12 and correlate this data with a field snow immersion studies conducted earlier. The study concludes with prevention tools and strategies.
It is clear that more work remains regarding public education about the SIS risk at U.S. ski areas. The greatest single component of snow immersion risk is that it continues to be substantially under-appreciated.

KEYWORDS: snow immersion, suffocation, SIS, NARSID, ski area, risk management, ski safety, skier education

1. INTRODUCTION

Snow Immersion Suffocation (SIS) occurs when the victim, usually a skier or snowboarder, falls while skiing in new powder snow within the boundaries of a developed ski area but off of a groomed ski trail. The victim is either alone or the fall is not witnessed by the victim’s partners. They become immobilized, usually in the inverted position, in unconsolidated snow. Subsequently the victim is unable to self-extricate. This phenomenon is often associated with tree wells but any immersion in deep snow, particularly in the inverted position is potentially lethal.

From 1990/91 to 2011/12, there have been sixty-four (SIS) cases reported. For comparison of inherent risks at ski areas during the same period there have been sixty avalanche fatalities resulting from ticketed skiers leaving the designated ski area boundary (out of bounds) and 9 avalanche fatalities that have occurred within ski area boundary (in bounds).

Of these three categories of inherent risk at ski areas it is clear that SIS presents the greatest challenge to skiers and operational personnel.

Avalanche fatalities at North American ski areas have been well documented. In earlier studies (Cadman, 1999) found that from 1993-1998, 25% of ski area fatalities in British Columbia were NARSIDs and (Hackett, 2000) found in the period from 1985-1995 the NARSID risk was ten times greater than the risk of an avalanche burial at a U.S. ski area.
This study shows that between 1990/91 and 2005/06, the risk of SIS at U.S. ski areas is currently six times greater. Another important difference is that avalanche risk, both in bounds and out of bounds, is well understood and has been targeted with a robust public awareness and educational campaign.

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The need to increase risk awareness among snow and avalanche professionals is clear. The goals of this research were to:

- Compare SIS data to avalanche fatality data to determine risk trends.
- Develop information to explain these trends.
- Maintain a current database of all reported SIS cases in North America, obtaining detailed reports on specific cases wherever possible.
- Correlate this data with information obtained from a field experiment with human subjects.
- Incorporate the findings in development of educational materials for use by the public including website, brochure, signage, and technical notes for snow and avalanche personnel responding to SIS events.

The good news is that SIS risk, like avalanche risk, can be managed using awareness, sound personal, and partner technique, and ski area risk management procedures.

2. METHODOLOGY

2.1 *Inbounds and out of bounds avalanche fatality statistics*

Analysis was conducted on sixty-four individual SIS cases occurring in the U.S. between 1990/91 - 2011/12 out of a total of 96 known cases, field experiment results, and accounts from snow immersion survivors.

Avalanche fatalities, both in bounds and out of bounds, for U.S. ski areas are well documented and accident and statistical data were obtained through the Westwide Avalanche Network. Specific U.S. ski area avalanche statistics were also obtained (Atkins, personal communication). The ski area in bounds category was limited to cases that occurred while the ski area was operating and in areas designated as open. The ski area out of bounds category included ticketed customers that used lifts to access terrain beyond the designated ski area boundary.

2.2 Snow Immersion Suffocation database

Snow Immersion events are not well reported and the data was much harder to come by. The SIS data set currently contains ninety-six reported cases in the U.S. and British Columbia from the early 70's to the present. This number is certain to be understated. Initial development of the SIS database was in collaboration with Dr. Jasper Shealy, Data on British Columbia accidents (Cadman, 1999) and (Bezzola personal communication) was also provided. The database was further developed through the investigation of individual cases. Ski area and heli-ski operations personnel, and in some cases even the victims partners, provided more detailed information on the circumstances of snow immersion accidents.

The selection criterion for inclusion in the SIS dataset is any snow immersion death as a result of asphyxia except avalanche burial. Cause of death attributed to avalanches, trauma, or hypothermia, are excluded from the data set. For example, if the subject in a tree well immersion accident suffered fatal head and neck trauma as a result of hitting the tree, the case was excluded.

The data used in this study was limited to U.S. cases occurring between 1990/91-2011/12. With the exception of two out of bounds cases all of the reported SIS fatalities have occurred within developed ski areas boundaries.

This data was analyzed for common factors, patterns, statistical trends, and any factors that may be used to develop SIS prevention strategies.

2.3 *Incorporation of findings from earlier field snow immersion experiment*

Analysis of the database was combined with information obtained from a field snow immersion experiment conducted with human subjects. The experiment was conducted on March 19, 2006 at the Crystal Mountain ski area in Washington State.

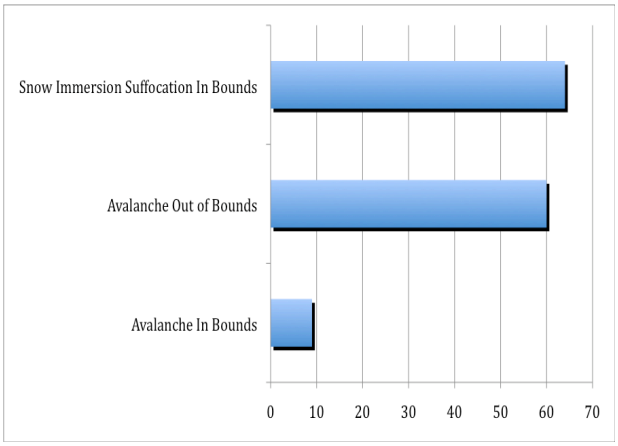
The test subjects were placed in a tree well in an inverted body position with their heads submerged. They were buried to various depths up to 1.5 m. The various degrees of inversion selected were based on data from documented cases in the database. Half of the test subjects had alpine ski equipment and the other half had snowboards.

The principal goal of the experiment was to measure the subjects' abilities to maintain an airway and successfully extricate themselves. Information learned from this experiment was used to supplement the case data to develop prevention strategies.

3. RESULTS AND DISSCUSSION

3.1 *Comparison of the risk trends of in bounds and out of bounds avalanche fatalities and snow immersion suffocation events at U.S. ski areas*

The data range selected for statistical evaluation of risk trends was from 1990/91 to 2011/12. Based on the selection criterion noted in 2.1 the total number of reported avalanche fatality cases occurring in bounds at U.S. ski areas was nine. There were also sixty reported avalanche fatalities occurring to ticketed lift skiers venturing beyond the ski area boundary.
During the same period there have been sixty-four SIS cases reported. This is illustrated in figure 1.



The key findings in the risk analysis are:

- Despite a recent spate of inbounds avalanche fatalities the risk to in bounds skiers at developed ski areas has been reduced to an incredibly small number. This is a testimonial to the success of modern ski area avalanche control programs. This of course, comes with the caveat that skiers must respect posted ski area closures and understand that they are putting themselves at increased risk when they ski in steep avalanche prone terrain in bounds.

- The trend in the number of out of bounds avalanche cases continues to stay at a fairly constant rate. There is a clear trend that more ski area customers are skiing on Alpine Touring (AT) gear and using the lifts to access backcountry terrain. Since the actual number of out of bounds users is unknown it can only be assumed that this flat trend actually represents a per capita decrease in the risk. This would be another testimonial to the excellent avalanche awareness and boundary management programs at ski areas.

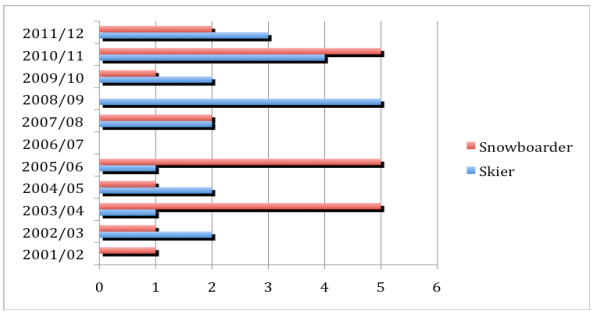
- The risk trend at U.S. ski areas for Snow Immersion Suffocation correlates well with the risk of out of bounds avalanche fatalities. It should be noted that SIS events also correlate well with large precipitation events and high avalanche danger. These two factors may keep skiers and snowboarders in area as conditions are good and out of bounds travel is difficult or dangerous.

- It is interesting to note that seasonal snowfall amounts may play a significant role in the level of each risk. The 2010-2011 season was characterized by generous snow totals at most western ski areas. This was great for powder skiing but also yielded a record year for (9) SIS fatalities. Paradoxically, the following 2011-2012 season was one of meager precipitation totals at most western U.S. ski areas. The related inherently weak snow packs resulted in another record year but this time it was (8) out of bounds fatalities.

3.2 *Analysis of the SIS data*

Continual updating and analysis of the SIS database provides the most useful information for risk prevention. It currently stands at ninety-six cases from the U.S. and B.C. This includes seventy-one cases in the U.S. with only two of those cases (3%) occurring outside of a developed ski area's designated boundary. There are twenty-five documented cases in B.C. with fourteen of those occurring at ski areas and eleven cases related to mechanized ski guiding. Previously un-documented cases, or cases that were not initially identified as a SIS event, are being continually added to the database.

This data was used to create a profile of the environmental characteristics and human behavior present during these events. This information has been used to develop prevention strategies.



The key findings of the database analysis are:

- Skiers and snowboarders are evenly at risk (fig. 2). During the period from

1990/91 to 2011/12 the dataset contained twenty-two skiers and twenty-three snowboarders,

- When correlated with data from the U.S. National Ski Areas Association (NSAA) SIS events represented 10% of the total alpine skier fatalities and 15% of the total snowboarder fatalities. There is an opportunity for education here.

- Most SIS events continue to occur in the western U.S. and Canada. A steep, thick coniferous forest, combined with deep powder, is the prime environment. Tree wells have been involved roughly 70% of the SIS cases but deep snow immersions still occur in open terrain often around rocks and drainages. The thick branches of a fir tree support the snow and form air pockets around its trunk. The low-lying branches at the surface also hide this airy well at its base. The victim passes through more easily with the downward bending branches then trying to come out against them. Additionally, a substantial load of snow from those branches can accompany them into the well. The lesson here is to grab the branches to help prevent inverting.

- January and December account for 40% of the accidents when the snowpack is generally weak and the base of tree wells have not had a chance to consolidate.

- Big precipitation events are usually associated with SIS events. The risk of snow immersion increases dramatically when there has been 2 m or more new snow within the previous 48 hours. It is not uncommon for snow immersion and avalanche accidents to occur locally within days of each other. However, anytime the snow structure in the upper part of the snowpack is weak to a depth of a meter or more there will be the potential for snow immersion.

- Most SIS victims have been with partners that did not witness the fall and subsequent immersion. This may be the most important step in reversing the outcome once snow immersion has occurred. Some of the victims in the dataset were skiing or riding alone but the majority had partners. Maintaining partner contact is crucial so that partner rescue can occur. Educating ski area skiers effective strategies to maintain contact with their partners should be a primary goal.

- Ski area personnel may find it useful to develop a missing person report response that considers the urgency required based on the current level of snow immersion risk. Since the victim often has an exposed body part or piece of equipment visible on the surface an immediate response to the general area has proven life saving is some cases. This can be done while taking the witness and additional rescue personnel and equipment, including avalanche dogs, to the last seen area.

- The most important step is raising the level of awareness. Ski area personnel must be informed of the correct safety message to deliver to the customers. The customers can then be educated with the help of web site content, brochures, ski area signage, and safety talks. The important prevention steps include how to avoid the risk, how to ski or ride defensively during snow immersion conditions, and effective strategies for skiing with partners, and what to do if they do go down. Emphasizing the skill of keeping partners in continuous visual contact is of paramount importance.

3.3 *Correlation with the earlier field snow immersion experiment*

The experiment demonstrated that self-extrication by the subjects ranged from very difficult to impossible. The ability of the test subjects to extricate themselves from the tree well was dependant primarily on the degree of the inverted body position and the depth of burial.

The time window for the test subjects to manage useful activity like securing an airway, or maneuvering their arms and legs was very short. We also confirmed that releasable ski bindings do not guarantee a successful extrication as has been suggested for snowboarders. It should be noted that these results also correlate well with a similar experiment done at Blackcomb, British Columbia where none of the subjects were able to extricate themselves including the alpine skiers. The skiers in that experiment almost all successfully kicked off their first ski and those who got the second ski off tended to fall deeper into the hole and remained upside down (Cadman, personal communication).

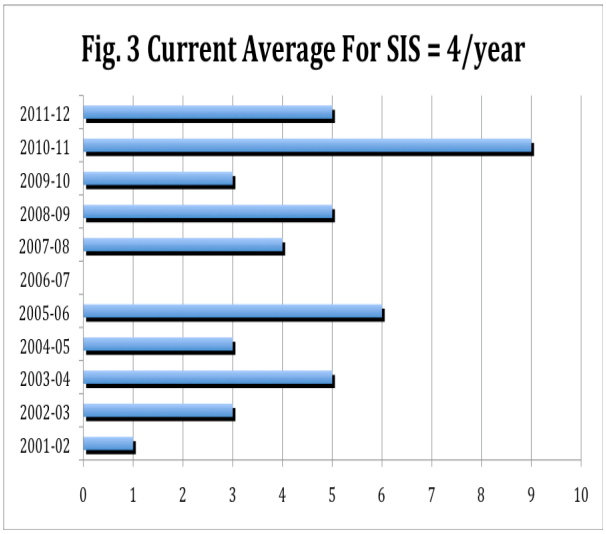
The ability of the test subjects to establish and or maintain an air pocket could be affected by their attempts to extricate. This confirms the accident data that it is difficult to impossible to escape without a competent partner's help. It also suggests that while an attempt to escape should be made it is more important to protect the air pocket and hope that a partner is coming to the rescue.

As in any burial in the snow, survival time is extremely short. None of the test subjects made it to the mandatory removal time of two minutes. This confirms that in many cases the time between immersion and death can be extremely short. One another earlier study found that in a sample of twenty cases, six were unburied in less than thirty minutes and three in less than fifteen minutes (Hackett, 2000).

To underscore this, we had a survivor of a recent tree well burial present during this experiment. She had stopped breathing before being recovered by her partner in less than ten minutes.

4. CONCLUSIONS AND THE DEVELOPMENT OF PREVENTION STRATEGIES

Based on the findings of this study it is clear that more work remains regarding public education about the SIS risk at U.S. ski areas. The greatest single component of snow immersion risk is that it continues to be substantially under-appreciated. With an average of just over four SIS fatalities each ski season in the last ten years (fig. 3)



It also accounts for an average of ten percent of all ski area accidental deaths on an annual basis it has become one of he most significant inherent risks in the sport of alpine skiing and snowboarding. Recent progress has been made in the development of educational awareness and prevention tools. This includes the following:

- Snow Immersion Suffocation Website www.deepsnowsafety.org

This site was developed with Gwyn Howat/ Mt Baker Ski Area and contains current information and has a section on technical notes for professional rescuers as well a place to report snow immersion near misses. First hand accounts by survivors of snow immersion including both self and partner rescue techniques have proven invaluable. Now there will be a place for all to see that information.

- NSAA Snow Immersion Suffocation Brochure

This brochure was developed in cooperation with the U.S. National Ski Areas Association (NSAA) and Gwyn Howat/ Mt Baker Ski Area. It is available by contacting the NSAA at nsaa.org.

- Signage

Warning signage has been developed that can be used at times of increased snow immersion risk or for general warning throughout the ski season.

The following prevention strategies and tactics are suggested:

1. Prevention

• Avoid deep snow and treed areas. Staying on groomed runs will greatly reduce your risk.

• If you make a choice to ski off the groomed trails be aware of the snow immersion suffocation potential.

• Check local sources and be aware of the recent snowfall and the depth of the loose snow.

• Carry safety equipment. Consider a communication device like a radio or cell phone with local ski patrol or resort emergency number if possible, whistle, shovel, probe, avalanche beacon, *Avalung, RECCO*.

• Ski in control and give tree wells a wide berth. Look at the open spaces between trees not the trees. Don't use ski pole straps.

• Keep your partner in sight at all times! Most of the SIS victims have had part of their body or equipment visible to the surface but their partner wasn't there to see it.
•Take heart. With increased awareness there are more reported cases of skiers and boarders being rescued by their partners each season.

2. Maintaining Partner Contact

Keep your partner in sight at all times!

•More than half of all SIS victims were with partners that did not see them go down. Lose sight of your partner and you could lose your friend.

•In dense trees or bad visibility due to storms ski or ride short pitches and stop to regroup to remain in contact.

•Have a plan if you lose contact with your partner. If you lose contact assume your partner needs immediate help. Many SIS victims have died while their partners were waiting patiently at the bottom of a lift.

Rescue
What to do if you go down

•Yell to get your partners attention.

•Do whatever you can to keep your head above the surface including, rolling, grabbing tree branches or the trunk. At least try to keep your feet below your head.

•If you become immersed make a space around your face and protect your airway. If you can't get out resist further struggling. This can compromise your airspace and lead to further entrapment.

•Stay calm and conserve your airway. Trust that your partner is on their way.

Rescue
What to do if your partner goes down

•Don't leave to get help.

•Use a whistle or yell for help. If possible call the local ski patrol or resort emergency number in your cell phone.

•Do not try to pull victim out the way they went in. Instead determine where the head is and tunnel into it from the side.

Go directly for the airway, clear and maintain it. Be careful not to knock more snow into the hole as your partner is extricated.
This presents a great opportunity for the same ski area and snow professionals that have been so successful managing the risks associated with avalanche. This can be readily accomplished by providing the ski area customers with prevention strategies like those discussed above.

It should be noted that the heli-ski operations have been successfully managing this risk since the 70's. Strict adherence to the "buddy system", demonstration and prevention instructions to the clients, and sophisticated rescue gear have helped to reduce the snow immersion risk (R. Atkins, personal communication)

Many questions about the snow immersion phenomenon remain to be answered. Anyone with information on these events, including surviving snow immersion, are encouraged to contact the author of this paper.

ACKNOWLEDGEMENTS

Brad Stanford, a prominent ski defense attorney helped support much of this research, The compilation of the database would not have been possible without the help of Jasper Shealy, a recognized ski safety expert. Robert Cadman provided data, valuable insights, and continues to be very helpful in both research and prevention strategies for snow immersion accidents. Dale Atkins, Pascal Haegeli provided statistical information. Roger Atkins, Colani Bezzola, and many other ski area and snow safety professionals have shared details as well as their thoughts on a variety of snow immersion cases. Gwyn Howat has produced very good prevention materials. Members of the Crystal Mountain Volunteer patrol participated as subjects in the snow immersion experiment. My sincere appreciation goes to these valuable contributors.

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