# RISK OF DEATH AND MAJOR INJURY FROM NATURAL HAZARDS IN MECHANIZED BACKCOUNTRY SKIING IN CANADA

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ABSTRACT: Guests and guides partaking in commercial mechanized backcountry skiing are exposed to numerous natural hazards that can result in injury or death, but detailed quantitative risk estimates are currently lacking. This represents a considerable barrier for evaluating existing risk management practices and implementing evidence-based interventions. We collected historical incident and exposure information from helicopter- and snowcat-skiing operations in Canada to perform a retrospective risk analysis. Our results show that avalanches are the largest contributor of the overall risk of death in mechanized skiing, followed by tree wells and other non-avalanche related deep snow immersions. However, the risk of death from avalanches decreased substantially over the entire study period from the 1970 to the 2016 winter season. Avalanche risk is substantially higher in helicopter-skiing than in snowcat-skiing, but other snow immersion fatalities are more common in snowcat-skiing. The risk of major injury is primarily associated to unforced skiing accidents and collisions and shows higher values for guides in snowcat-skiing than helicopter-skiing.

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KEYWORDS: Mortality risk, morbidity risk, backcountry safety, adventure sport.

## 1. INTRODUCTION

Backcountry skiing is inherently risky as recreationists expose themselves to numerous types of natural hazards that can result in accidental injury or death. Examples of these hazards include snow avalanches, tree wells (Van Tilburg, 2010), cliffs, glacier crevasses, natural obstacles, as well as challenging travelling conditions. Several studies have estimated the risk of death associated with recreational backcountry skiing (Valla, 1984; Winkler et al., 2016; Zweifel et al., 2006). However, one of the fundamental challenges of this research is that while fatalities are generally well documented, obtaining reliable use or exposure information is extremely difficult due to the open access nature of these activities.

The data situation is very different in mechanized skiing, which refers to commercial backcountry skiing, where groups of paying clients led by professionally trained guides use helicopters or snowcats to access remote, pristine and uncontrolled skiing terrain that would otherwise be difficult to reach. Operators have kept detailed records of the number of skier days they provided to guests since the early beginnings of this industry in the 1960s and 1970s, as it is an important economic indicator. This dataset represents a unique, direct high-quality measure of exposure for risk calculations.

While fatal avalanche accidents are well documented in the mechanized skiing industry in Canada (e.g. Jamieson et al., 2010), fatalities from other causes and severe injuries have so far not been collected systematically. Hence, a comprehensive quantitative assessment of the risks in mechanized skiing has so far not been possible. This lack of quantitative understanding represents a considerable barrier for evaluating existing risk management practices and impedes the improvement of backcountry safety protocols within the mechanized skiing community.

This study aimed to address this gap of knowledge by:

a) Collecting a comprehensive dataset of historic incidents in mechanized skiing that resulted in fatalities or severe injuries;

b) Computing the risk of death and injury from these hazards;

c) Exploring differences between the two types of mechanized skiing (helicopter versus snowcat) as well as guests and guides; and

d) Contrasting the calculated risks to other mountain sports.

## 2. METHODS

### *2.1 Data collection*

To perform a quantitative analysis of the risks of death and injury in the mechanized skiing industry, an extensive industry-wide dataset was collected. We used the concept of *'skier days'* to

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describe exposure. One skier day represents one skier exposed to backcountry hazards for the duration of one ski day. HeliCat Canada—Canada's trade association of mechanized skiing—recorded the number of *'guest skier days'* by operation and season since 1995. Earlier figures from 1970 to 1995 were based on annual, industry-wide estimates that were presented during industry meetings in the late 1990s (W. Bruns, personal communication, May 2017). Missing data or information from non-HeliCat Canada members were completed by requesting skier day information directly from specific operations. Since '*guide skier days'* have not been recorded systematically within the industry, they had to be estimated. Based on industry expert advice, we assumed an average guide to guest ratio of 1:6 for the entire study period to overcome this issue (I. Tomm, personal communication, April 2017).

Information on serious incidents in the mechanized skiing industry was collected from various sources within and outside the industry. Main sources included existing accident databases and publications (e.g. Jamieson et al., 2010), existing records of HeliCat Canada, fatality investigation reports of the British Columbia Coroner Service (BCCS), and anonymized worker compensation claim records of WorkSafeBC. All the found records were entered into a database and classified according to incident type (snow avalanches, collisions, glacier crevasses, falls from height, tree wells, other non-avalanche related snow immersions, and unforced skier accidents), type of operation (helicopter- vs. snowcat-skiing), type of patient (guest vs. guide), and severity of injury (major vs. minor injury).

### *2.2 Risk calculations*

Since the quality of the collected exposure and incident data varied considerably during the study period, we focused in the following four research questions:

a) Risk of death from avalanches for the entire study period (1970 to 2016 winter seasons);

b) Risk of death from all natural hazards (1997 to 2016);

c) Risk of major injury for guides from all natural hazards (2007 to 2016);

d) Risk of major injury for guests from all natural hazards in helicopter-skiing (2007 to 2016);

Risk estimates were calculated by dividing the number of patients with injuries of a specific severity by the number of skier days for the operation type, patient type and time period in question. In cases where we were confident that our dataset was comprehensive and covered the entire industry (e.g., risk of death, risk of major injury for guides), the calculated value describes the true risk for the entire industry. In cases where we had incomplete information (e.g., guest injuries), we limited the data included in our calculations to operations and seasons with systematic incident recording procedures/systems where we were confident to have complete records of incidents at all severity levels. We then extrapolated the derived risk estimates to the entire community by calculating 95% confidence intervals relative to the total number of industry-wide skier days.

In the final step of our analysis, we compared our risk estimates for mechanized skiing with other mountain and adventure sports based on figures published in the medical literature.

## 3. RESULTS & DISCUSSION

The following paragraphs provide a brief overview of the main results of our study. A manuscript that describes the results in detail is currently under review for publication in the peer-reviewed journal *Wilderness & Environmental Medicine*.

### *3.1 Risks of death and major injury*

Our complete analysis dataset spans 47 winter seasons from 1970 to 2016 with a total of 3,258,000 skier days and 713 incidents that resulted in injuries or fatalities among guests or guides.

We estimate the overall risk of death from natural hazards in mechanized skiing for guests and guides to be 18.6 fatalities per million skier days (1997 to 2016). While the risk of death from avalanches decreased substantially over the entire study period from 1970 to 2016, avalanches are still the largest contributor to the overall risk of death (77%), followed by tree wells (12%) and other non-avalanche related deep snow immersion (8%). We attribute the dramatic and steady reduction in the risk of death from avalanches to the increased avalanche safety expertise within the industry and generally advanced avalanche search and rescue equipment.

The risk of major injury is primarily associated to unforced skiing accidents and collisions and shows higher values for guides in snowcat-skiing than helicopter-skiing.

Observed differences in the risks of death and injury between helicopter- and snowcat-skiing seem consistent with differences in the typical type of terrain skied by snowcat- and helicopter-skiing operations. The more alpine terrain skied by helicopter-ski operations is reflected by the

higher risk of death from avalanches, whereas the treeline and below treeline terrain more commonly skied in snowcat-skiing operations results in a higher risk of snow immersion incidents as well as skiing accidents and collisions.

### *3.2 Comparison to other mountain sports*

Our literature review revealed that the estimated overall risk of dying in mechanized skiing over the last 20 winters is higher than in alpine resort skiing (e.g., Corra et al., 2004; Ruedl et al., 2011; Tough & Butt, 1993) and hiking (e.g., Burtscher et al., 1994), but lower than in mountaineering (e.g., McIntosh et al., 2008).

Our morbidity estimates for guides and guests indicates that the risk of getting seriously injured in mechanized skiing is higher than in indoor climbing (e.g., Limb, 1995; Schöffl et al., 2013), but lower than in rock climbing (Schussman et al., 1990), alpine skiing and snowboarding (Aschauer et al., 2007) and competition climbing (Schöffl & Küpper, 2006).

### *3.3 Limitations*

There are a number of data challenges that limit our ability to provide deeper insight. Issues directly affecting the present study include limited information on injuries and no direct records of guide ski days. In addition, the lack of information on exposure time of non-guiding staff and pilots as well as information on seasonal flight and driving hours prevented the inclusion of non-natural hazards (e.g., lodge and flight incidents) into the analysis and providing an even deeper, more accurate and more comprehensive perspective on the risks involved in mechanized backcountry skiing.

## 4. CONCLUSIONS

Our analysis provides a comprehensive overview of the risks of death and major injury from natural hazards in mechanized backcountry skiing in Canada and offers insight into current and past trends and patterns. The simultaneous availability of high-quality fatality, injury and exposure data allowed the calculation of risk estimates at an accuracy that is rare for outdoor recreation activities. To facilitate future research in this area, we encourage the development of data systems that support the systematic recoding of incident information and exposure data in the avalanche community.

## CONFLICT OF INTEREST STATEMENT

This study was funded by HeliCat Canada, Canada's trade association of mechanized skiing operators.

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