FATAL OCCUPATIONAL INJURIES OF AVALANCHE WORKERS IN NORTH AMERICA

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ABSTRACT: In the United States, since the 1950s the annual number of avalanche workers killed by avalanches has averaged 0.6. The ten-year averages over this period have been as low as 0.2 and peaked at 1.4 in the last decade. In the last 5 years, 12 avalanche workers have been killed by avalanches while at work. In Canada from 1982 to 2002, the number of avalanche workers killed by avalanches averaged about 0.6 per year, but there has been only one death since 2003. To promote discussion of avalanche industry controls on worker risk, we compare the rate of fatal avalanche injuries of avalanche workers in North America with other occupational categories tracked by federal government groups. Our estimates would place avalanche work among the occupations with high fatality rates. We hope this will promote discussion of the relative and acceptable risk to avalanche workers.

KEYWORDS: worker safety, risk management, fatal occupational injuries, avalanche accidents

1. INTRODUCTION

Many people consider avalanche work a dangerous job, but just how dangerous is it? Although avalanche workers are killed on the job, the small number of workers, dispersed operating areas, and historically few accidents makes it difficult to determine the relative threat. Recent trends in worker deaths in the United States and Canada are opposite, with no deaths since 2006 in Canada and 12 deaths in the five years (since 2009) in the U.S. Is avalanche work getting more dangerous? Safer? Is it dramatically different in the U.S. and Canada? It is difficult to answer any of these questions without examining industry trends and comparing different occupations in both countries.

Evaluating worker safety is an important part of any industry. The results can affect business and operational decisions at all levels of an industry. In North American, state, provincial, and federal government groups collect data on occupational injuries and examine trends. Common approaches of previous efforts are to look at regional differences and changes over time (Benavides el al. 2005; Loomis et al. 2003; Rossignol and Pineault 1993) or social, racial, or economic impacts on fatal occupational rates (Loomis et al. 2009; Loomis et al. 2004; Loomis and Richardson 1998; Richardson and Loomis 1997).

We have collected data on fatal accidents of avalanche workers to evaluate the worker's risk and compare it to other industries and occupations. We hope that this effort will encourage discussions on the relative and acceptable risk to avalanche workers and promote efforts to track the industries' progress and promote safe working environments.

2. METHODS

There are many occupations where people need to address the threat of avalanches. Although government groups in both the U.S. and Canada collect data on workplace accidents, the number of people who work in avalanche safety is relatively small compared to other fields and they could fall into several different occupational categories. There are no datasets of avalanche workers, or even an established definition of what an avalanche worker is, which makes examining workplace injuries of this group extremely difficult.

For the purpose of this study, we defined an avalanche worker as *a person who makes avalanche safety decisions for other people or travels in avalanche terrain to collect data for such decisions as part of their occupation* and a fatal occupational injury as *an injury that leads to death as the result of an occupational accident.* The Organization for Economic Cooperation and Development (www.oecd.org) uses a similar definition for occupational fatalities, but stipulates that the death must come within 1 year of the accident.

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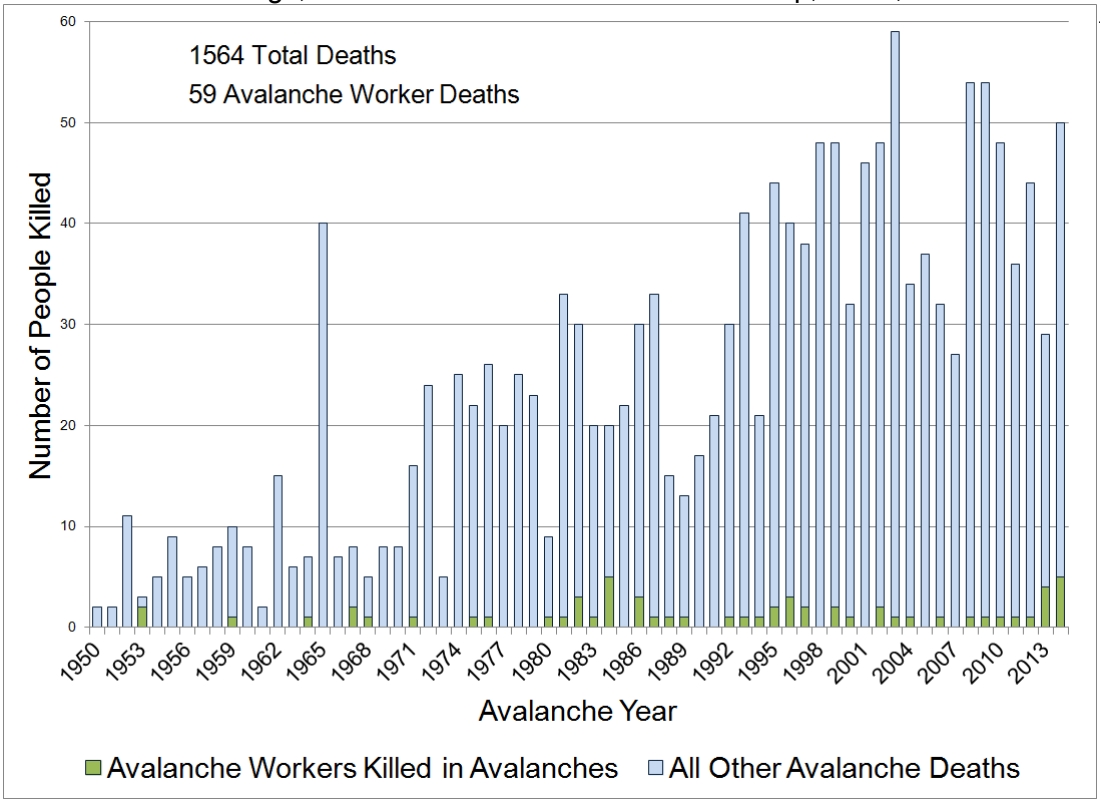

Fig. 1: Total people killed in avalanches and avalanche workers killed in avalanches in North America from 1950 to 2014.

Tbl. 1: Estimated exposure values for avalanche workers in Canada

Industry Sector	Estimated Number of Avalanche Workers	Average Number of Days in Uncontrolled Avalanche Terrain	Total Worker Days in Uncontrolled Avalanche Terrain
Mountain Guiding	250	80	20000
Highways and Parks	40	40	1600
Ski Areas	250	43	10750
Consulting and Research	40	30	1200
Snowmobile Guiding and Other	40	40	1600
Total	620		35,150

Tbl. 2: Estimated exposure values for avalanche workers in the United States

Industry Sector	Estimated Number of Avalanche Workers	Average Number of Days in Uncontrolled Avalanche Terrain	Total Worker Days in Uncontrolled Avalanche Terrain
Mountain Guiding	400	80	32000
Highways/Industry	45	45	2025
Ski Areas	2220	70	155400
Consulting and Research	60	25	1500
Government Public Safety	55	100	5500
Total	2780		196,425

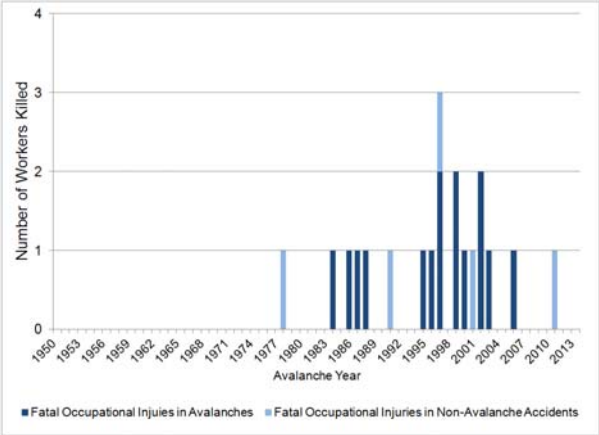

Fig. 2: Fatal occupational injuries of avalanche workers in Canada.

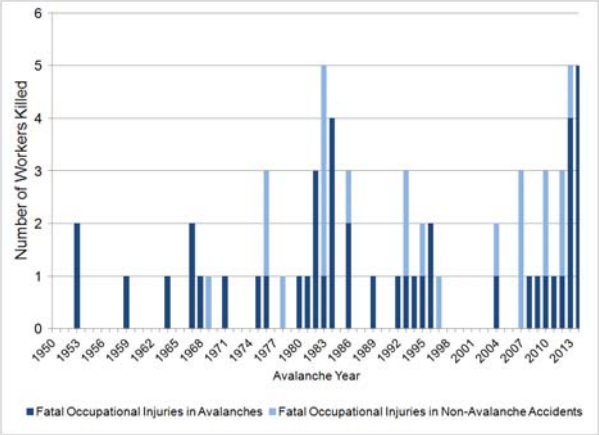

Fig. 3: Fatal occupational injuries of avalanche workers in the United States.

During our investigation we did not find any accidents where the source of the fatal injury was in question. The nature of the accidents we reviewed to form our dataset made this criterion unnecessary.

We reviewed the avalanche accident databases for the U.S. and Canada to select cases that fit these definitions. We erred on the side of inclusion, retaining cases where the workers made avalanche safety decisions for coworkers. In several cases we included interns and junior workers in research and avalanche safety groups. This effort produced a dataset of avalanche workers, killed in avalanches, from 1950 to 2014 (Fig. 1). We grouped the events by year, using the *avalanche year* from Jamieson et al. (2010) where 2014 begins on October 1, 2013 and ends September 30, 2014.

We reviewed previous efforts to catalog fatal occupational accidents of avalanche workers (Morris, 2010), government reports, and media reports. To identify causes of death other than avalanches, we interviewed avalanche workers in different parts of North America. In a few cases old memories provided details of the accident, but not a firm date. In these cases we assigned the fifth year of the relevant decade (e.g. 1975 for events that occurred “in the 70s”). This effort produced a dataset of fatal occupational injuries of avalanche workers due to non-avalanche events. We combined these events with the set of avalanche worker deaths from the avalanche accident databases to form one collection of fatal occupational injuries of avalanche workers (Figs. 2 and 3). Our next task was to estimate the number of avalanche workers in the U.S. and Canada. We used different methods for each country.

For Canada we conducted interviews with experienced avalanche workers in Alberta and British Columbia. We created a list of ski areas in western Canada. For each area we included the number of avalanche workers and estimated the number of days they spent in avalanche terrain. We used estimates of user days to approximate the number of days guides spent in avalanche terrain (Tbl. 1).

For the U.S., we used descriptions of government avalanche safety programs (Ferber 2010; Trautman and Birkeland 2014) to estimate the number of workers and number of days in avalanche terrain. We surveyed state Departments of Transportation to determine the number of highway avalanche workers. We used membership information from the American Mountain Guides Association, Cat Ski US, and HeliskiUS to estimate the number of guides and assumed use patterns for each sector. We conducted interviews to estimate the number of consultants and researchers and their time in avalanche terrain. For ski area workers we collected the number of Type I explosives permits (individual permit) with an avalanche endorsement from the Colorado Department of Labor and Employment. Each is associated with a Type II explosive permit (company permit), which allowed us to create a dataset of the number of people using explosives for avalanche work at each ski area in Colorado. We assumed this included all of the ski area avalanche workers in Colorado. We also assumed that the distribution of avalanche program size at ski areas in Colorado is similar to the distribution of ski areas in the western U.S. We made a list of the ski areas with avalanche programs in the western U.S. and categorized them as small, medium, or large. To estimate the number of avalanche workers in each area, we assigned the value of the

25th, 50th, or 75th percentile of the Colorado dataset to each category. We combined these estimates with the Colorado numbers to get the number of ski area avalanche workers and assumed a use pattern for their exposure. We rounded all of the final values to the nearest five to get the total number of workers and their time in avalanche terrain (Tbl. 2).

Government groups in the U.S. and Canada collect information on occupational injuries. We used data on fatal injuries and fatal injury rates from Government of Canada, Labour Program (Human Resources and Skills Development Canada). We used similar data from the Bureau of Labor Statistics (www.bls.gov). These two groups report fatal injury rates in Fatal Injuries per 100,000 FTE (full time equivalent) (U.S. Bureau of Labor Statistics 2006). Since most avalanche jobs are seasonal, we scaled our estimates of total months in avalanche terrain up to 12 months so we could compare with the data collected by federal governments for other industries.

3. RESULTS

Our effort produced a dataset of fatal occupational injuries of avalanches workers with 86 deaths in 74 events. Fifty-nine of the North American avalanche workers were killed in avalanches and 27 died in non-avalanche accidents. From 1950 to 2014, 1564 people were killed in avalanches in North America. Avalanche workers made up 3.8% of the total avalanche deaths.

In Canada from 1950 to 2014, 15 avalanche workers were killed in avalanches and 5 by other causes (Tbl. 3). All but one of the avalanche accidents involved a single death (Tbl. 4). Nine of the 15 deaths occurred during ski, ice or mountain guiding (Tbl. 4); however, this is also the sector with the highest estimated exposure to uncontrolled avalanche terrain (Tbl. 1).

In the U.S. there were a total of 66 workers killed in 55 accidents. Forty-four were killed in 38 avalanche accidents and 22 were killed in 17 non-avalanche related accidents (Fig. 3). About 60% of both the accidents and deaths occurred in the ski area industry sector (Tbl. 5). Two thirds of the fatal injuries were caused by avalanches. Explosive accidents and falls were the next two most common types of accidents, together making up about 20% of the total deaths (Tbl. 3). In most of the accidents only one person was killed. Of the 55 accidents, two or more people were killed in 7 events. There were multiple fatalities in 5 of the 38 avalanche accidents and 2 of the 17 non-avalanche accidents.

Tbl. 3: Type of accidents for avalanche workers, 1950-2014

Type of Accident	Workers Killed US	Workers killed Canada
Avalanche	44	15
Explosion	8	1
Fall	6	1
Gas inhalation	3	0
Vehicle	1	1
Submersion	2	0
Collision	1	0
Aircraft	1	2

4. DISCUSSION

The federal governments of the U.S. and Canada track occupational injuries and report the number of fatal occupational injuries and the fatal injury rate each year by industry sector and occupation (Figures 4, 5 and 6). They use the same categories each year to track the trends. The number of fatal accidents in each category can vary, but there are often several to several thousand each year. In our dataset of fatal injuries of avalanche workers, the number of events per year ranges between 0 and 5. There are many years with no fatal injuries. Most of the years with deaths have only one or two. The small number of events in the avalanche industry makes comparing the trends with other industry groups quite difficult. This issue is compounded by the small number of workers in the avalanche industry compared to other high-risk occupations (Fig. 6). To address this issue we calculated multiyear averages of the number of fatal injuries and fatal injury rates for the industry groups commonly reported by the Canadian Department of Labour and the U.S. Bureau of Labor Statistics.

In Canada, the fatal injury rate across industry sectors ranged from 0 to 43.18 deaths/100,000 workers between 2002 and 2007, with an average of 9.69 deaths/100,000 workers. During the same time period the fatal injury rate in the Canadian avalanche industry was 21.06 deaths/100,000 workers. From 1999 to 2014 the annual fatal injury rate ranged from 0 to 126.34 and averaged 35.53 deaths/100,000 avalanche workers. Although this puts avalanche work as the second or third most dangerous industry (Fig. 4), it is important to

Tbl 4: Number of fatal occupational accident and avalanche workers killed in the Canada, 1950-2014.

Industry Sector	Avalanche Accidents		Non-Avalanche Accidents	
	Events	Killed	Events	Killed
Mountain Guiding	9	9	2	2
Highways/ Industry	3	4	0	0
Ski Areas	1	1	1	1
Consulting and Research	0	0	0	0
Snowmobile Guiding	1	1	0	0
Av. Course Instruction	0	0	2	2
Total	14	15	5	5

Tbl 5: Number of fatal occupational accidents and avalanche workers killed in the United States, 1950-2014.

Industry Sector	Avalanche Accidents		Non-Avalanche Accidents	
	Events	Killed	Events	Killed
Mountain Guiding	7	8	5	5
Highways/ Industry	3	4	4	7
Ski Areas	23	27	7	9
Consulting and Research	0	0	0	0
Public Safety	5	5	1	1
Total	38	44	17	22

remember that the numbers we used to calculate the fatal injury rate are small compared to those used for other industries. Our results are quite sensitive to the range of years we examine and our estimate of the number of avalanche workers.

In the U.S. the fatal injury rate across industry sectors ranged from 0.79 to 28.54 deaths/100,000 workers between 2003 and 2012, with an average of 6.98 deaths/100,000 workers. During the same time period the fatal injury rate in the U.S. avalanche industry was 21.6 deaths/100,000 workers. From 1999 to 2014 the annual fatal injury rate ranged from 0 to 89.93 and averaged 26.98 deaths/100,000 avalanche workers. This places the avalanche industry in the U.S. as the second or third most dangerous (Fig. 5). Avalanche work comes in 9th among occupations with high fatal work injury rates (U.S. Bureau of Labor Statistics) between construction laborers and electrical power-installers and maintainers. The fatal injury rate for U.S. avalanche workers during the last two years puts avalanche work in the top four, between logging workers and airplane pilots (Fig. 6). Our fatal injury rate calculations are again quite sensitive to the size of the dataset and the assumptions we made collecting the data.

Comparing standard occupational injury statistics for the avalanche industry with other sectors is a useful exercise, but since the annual values have significant variation it may be more useful to look at trends within the industry. We calculated a 5-year running mean of avalanche worker deaths involving avalanches (Fig. 7). Over the 64 years, there are multiyear periods with no worker deaths in both countries. However, these periods never occurred at the same time. There are no avalanche workers killed in Canada until 1984, with a peak in the early 2000s. The last Canadian avalanche worker was killed in 2006, and 2007-2014 is the longest period with no deaths in the last thirty years. In the U.S., two accidents with multiple fatalities occurred in 1983 and a series of accidents in the 1990s precede an extended period with no worker deaths. That trend changed dramatically in 2007 with one or more death each year since. There is an even more disturbing trend of 5 worker deaths in each of the last two years.

The rate of avalanche workers killed on the job in Canada declined around 2004. While several factors may have been influential, many Canadian avalanche workers and operation managers have attributed the decline to two changes: In 2001 the Canadian Avalanche Association introduced a revamped Level 2 program for avalanche workers including a landmark Module 1; In 2005, the CAA hosted a Continuing Professional Development (CPD) day entitled Professionalism at the Crossroads. Both of these programs involved an objective presentation of the accident rate of Canadian avalanche workers, promoted a frank and blameless exchange of near misses, and addressed relevant human factors.

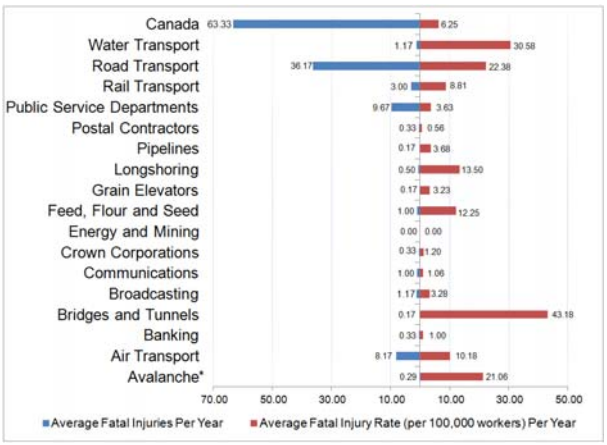

*Fig 4: Annual average of fatal injuries and fatal injury rate for Canadian industries from 2002-2007. The average fatal injury rate across industries is 9.96 deaths/100,000 workers. (*increased uncertainly due to small sample size and estimated exposure).*

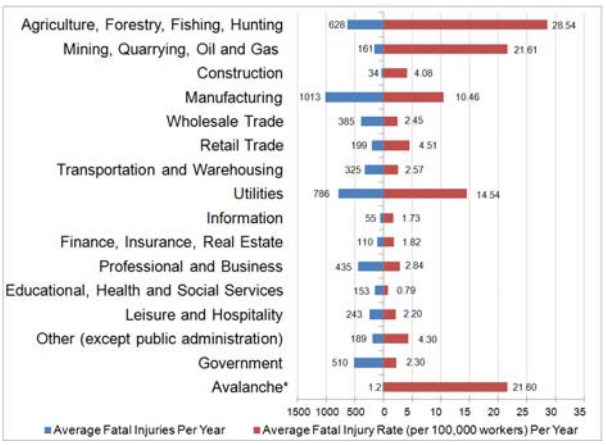

*Fig 5: Annual average of fatal injuries and fatal injury rate for U.S. industries from 2003-2012. The average fatal injury rate across industries is 6.98 deaths/100,000 workers (*increased uncertainly due to small sample size and estimated exposure).*

5. CONCLUSIONS AND RECOMMENDATIONS

Avalanche workers are exposed to danger while performing their job duties. There are several danger sources, similar to other outdoor occupations (U.S. Bureau of Labor Statistics 1995). However, avalanches are the major cause of death for avalanche workers.

Our estimate of the fatal occupational injury rate puts the avalanche industry near the top of all industry groups. The fatal injury rate also puts avalanche work in the top ten most dangerous occupations in the U.S. However, the number of avalanche workers killed in a given year is much lower than other occupations with a high fatal injury rate (Bureau of Labor Statistics 1995). Although we compiled data that allowed us to compare avalanche workers to other occupations,

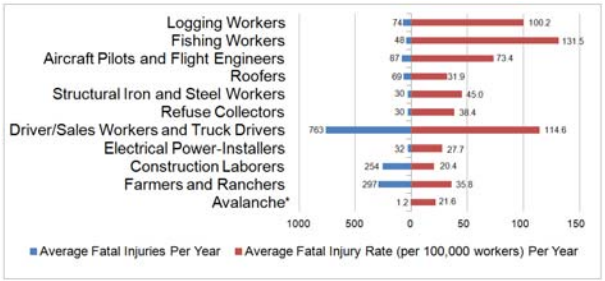

*Fig. 6: Annual average of fatal injuries and fatal injury rate for U.S. occupations with a high fatal work injury rate, 2003-2012 (*increased uncertainly due to small sample size and estimated exposure).*

the results must be viewed with a healthy dose of skepticism. We are confident the number of avalanche workers killed in avalanches includes a high percentage of the relevant events. Our confidence is lower for the set of non-avalanche fatal injuries, and there is no viable way to estimate the percentage of the events we captured. The number of avalanche workers and their exposure to avalanches is extremely important when evaluating worker risk and accident trends. Although we devised a method, our estimates could be off by 30% to 40%. Without a consistent source of employment data, it is very difficult to track trends in occupational injuries. Currently there is no government, industry, or professional group tracking avalanche workers or any of the sub-sectors (mountain guides, ski area, government public safety).

This study examined fatal occupational injuries. These are very important events for any industry and of special interest given the diverging trends in the U.S. and Canada. However, they tell only a small part of the workplace safety story. Non-fatal injuries and their severity are just as important, but currently there is no viable way to collect this information. To evaluate the relative risk to avalanche workers and to judge the effectiveness of any industry training or workplace safety program, we need a way of collecting and evaluating these incidents. This is important at all levels of the avalanche industry, from practitioner, to employer, to trainer, to trade group.

The avalanche industry is relatively small and often lacks the resources to collect and analyze

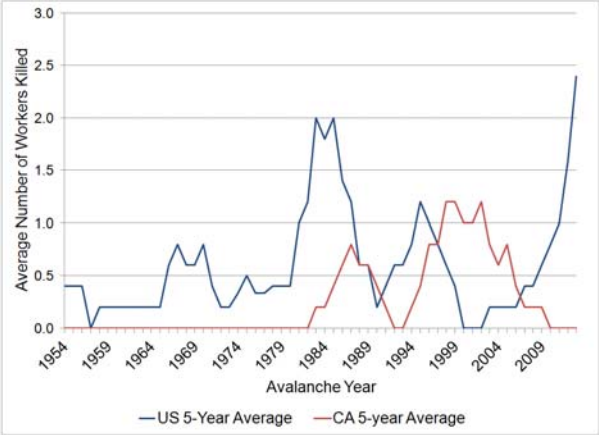

Fig. 10: 5-year running average of avalanche workers killed in avalanches in the U.S. and Canada.

internal processes the way larger industries do. However, we can look for solutions in other industry sectors. One approach that has been applied to occupations from emergency service workers to airplane pilots is the collection of near-miss events (i.e. www.nationalnearmiss.org for fire fighters). Establishing a blameless near-miss reporting system would allow the industry to track injuries, accidents, provide training material, and help us evaluate improvements or decline in the safety of our workplace. Another is the creation and adherence to workplace safety plans (avalanche plans). Careful creation and implementation can decrease occupational injuries (Lopez-Ruiz et al. 2013). While employee engagement is important for worker safety in general, we believe it is critical for avalanche work, which attracts (and needs) independent thinkers. Assessments of the factors contributing to the decrease in worker deaths in Canada since 2003 and the marked increase in the U.S. since 2009 would be worthwhile. It is clear that avalanche work involves exposure to danger, but options exist to improve the safety of avalanche workers.

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