

CAUSE OF DEATH IN AVALANCHES IN COLORADO, USA: A 31-YEAR REVIEW INTERNATIONAL SNOW SCIENCE WORKSHOP 2026, WHISTLER, CANADA

Spencer Logan^{1*}, Dale Wang MD¹, Alison Sheets MD¹, Ethan Greene¹

1 Colorado Avalanche Information Center, Denver, CO, USA

ABSTRACT: We examined the causes of death for 178 avalanche fatalities in Colorado, USA, between 1995 and 2026. We utilized data from the Colorado Avalanche Information Center (CAIC) database and official records from county coroners, including autopsy when available. Asphyxiation is the primary cause of death, accounting for 65% of fatalities, while trauma accounts for 22%. Annual fatalities showed high volatility without a significant linear trend. There was an increase in the proportional deaths attributed to asphyxiation in the 2016 to 2025 period. We calculated Injury Severity Score (ISS) for 100 cases. Victims assigned trauma as cause of death had significantly higher ISS scores than those who died from asphyxiation. Some victims assigned asphyxiation also exhibited significant traumatic injuries, underscoring the importance of autopsies when possible. We found no significant differences in the cause of death based on activity or avalanche type, suggesting that the asphyxiation-to-trauma ratio is a persistent characteristic of avalanche fatalities in Colorado. Our findings reinforce the continued importance of interventions to reduce the potential for asphyxiation--avoidance, reducing burial depth, and rapid rescue. Serious traumatic injuries among almost a quarter of victims highlight the need for rescuers to be prepared for both burial and complex trauma scenarios. Future research will continue to leverage improved collection methods for non-fatal avalanche injuries to further refine our understanding of these hazards.

KEYWORDS: avalanche fatalities, avalanche accidents, asphyxia, trauma.

1. INTRODUCTION

Over the past 31 years, from 1995 to 2026, avalanches have caused more than 178 deaths in the state of Colorado, USA. We examined the cause of death in these avalanche fatalities. We collected the cause of death as recorded by county coroners, the governmental agents responsible for determining the cause and manner of unexpected deaths in Colorado. When possible, we obtained and analyzed autopsy records to examine the frequency and severity of traumatic injuries. We compared the cause of death with activity and avalanche characteristics. This research builds on Sheets et al. (2018).

2. METHODS

2.1 Dataset

We reviewed all snow avalanche deaths in the Colorado Avalanche Information Center (CAIC) database for the avalanche years (CAIC, 2026) 1995 to 2026. We excluded one case where an avalanche was not the primary contributor to the fatality, and two cases where the avalanche was confined to sliding just off a building roof because

the sample was small and the mechanism of injury different than other avalanches. Our dataset included 178 fatalities caused by 159 avalanches.

2.2 Data collection and abstraction

CAIC records included date, group size, demographic information about victims, mode of travel, and avalanche type, trigger, and destructive size (CAIC, 2026; Greene et al. 2022). We contacted individual county coroners to obtain records about victims including the official cause of death and the autopsy report if one was performed. We requested records from 26 separate county coroners.

Investigators (AS, DW) abstracted mortality data after training by a hospital-employed trauma registry coordinator. For all cases, cause of death was assigned based on the coroner's official determination of the principal cause of death. Other data abstracted included organ systems involved, and type of injury sustained, if any. If an autopsy was performed, investigators calculated an Injury Severity Score (ISS). The Injury Severity Score (Baker et al., 1974) is an anatomical scoring system for injured patients based on the Abbreviated Injury Scale (AIS). An AIS is assigned to each of six body regions; the three highest-scoring regions are individually squared and then added together to produce the ISS. Values range from 0 to 75, with severe trauma defined as a score greater than 15.

* Corresponding author address:
Spencer Logan, Colorado Avalanche Information
Center,
Denver, CO, 80203;
Tel: +1 303-499-9650
email: spencer.logan@state.co.us

2.3 Analysis

We binned the cause of death by 10-year periods. That choice was made to reduce the annual volatility, provide bins with sufficient numbers of cases, while still allowing us to examine change through time. We examined both actual and proportional values. We used Fisher's exact, chi-squared or Kruskal-Wallis tests as appropriate to determine statistical significance.

3. RESULTS

3.1 Annual fatalities

Colorado averaged six avalanche fatalities per avalanche year. There was no significant linear trend through time. The annual number of deaths was highly volatile. Higher-degree polynomials did not improve model fit after accounting for model complexity. Three, five, and seven year trailing averages captured some variation, but the seven-year trailing average ranged from 5 to 6, suggesting any trends occur over periods shorter than 7 years.

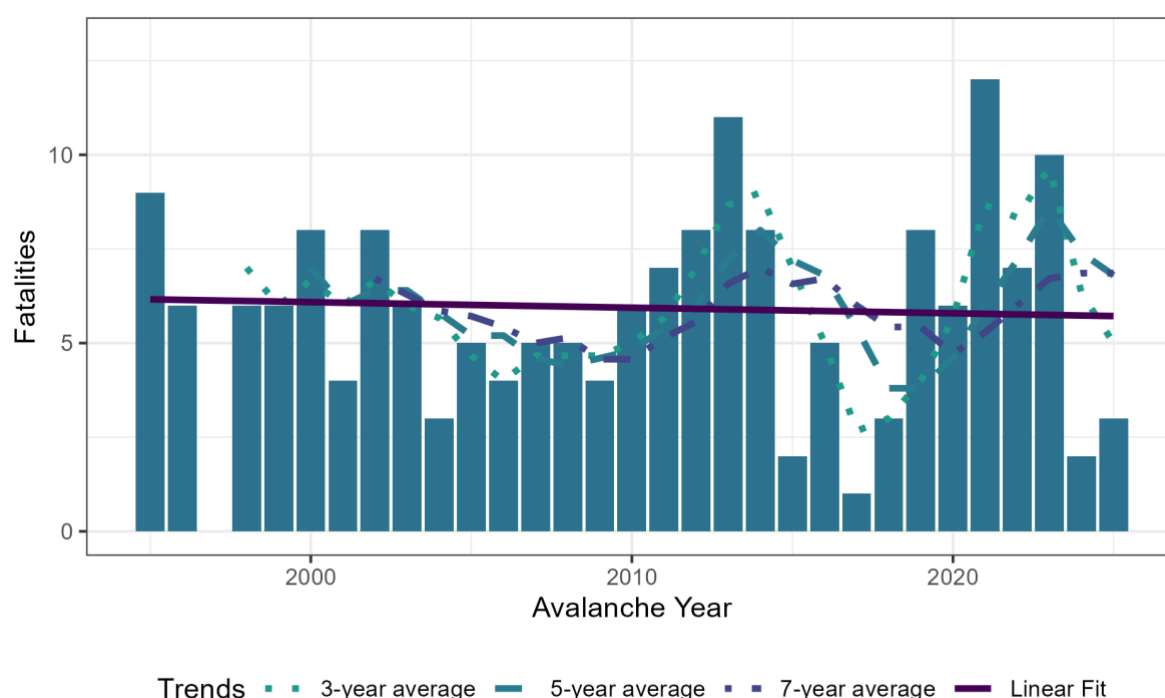


Figure 1. Avalanche fatalities included in our analysis, summed by avalanche year. Linear trend, three, five, and seven-year trailing averages are plotted as lines.

3.2 Cause of death

Asphyxiation was the assigned cause of death for 65% of victims in the complete dataset, while trauma was 22% (Table 1). We were unable to assign an official cause of death to 15 cases. Even if all 15 cases were due to trauma, asphyxiation would account for more than twice as many deaths. The proportion of asphyxiation to trauma was similar for the cases with autopsy and without. That suggests that victims who underwent autopsy are representative of our entire data set.

Table 1. Officially assigned cause of death

Cause of death	Count	Percent of total
Asphyxiation	115	65%
Trauma	40	22%
Unassigned	15	8%
Hypothermia	4	2%
Drowning	2	1%
Other	2	1%
Total	178	

The cause of death shows changes by decade, though they are not significant (Fisher's exact: $p = 0.213$). The proportion of asphyxiation (Figure

2) increased over time, from 70% to 86%. Trauma shows a drop in proportion, particularly in the 2016 to 2025 period.

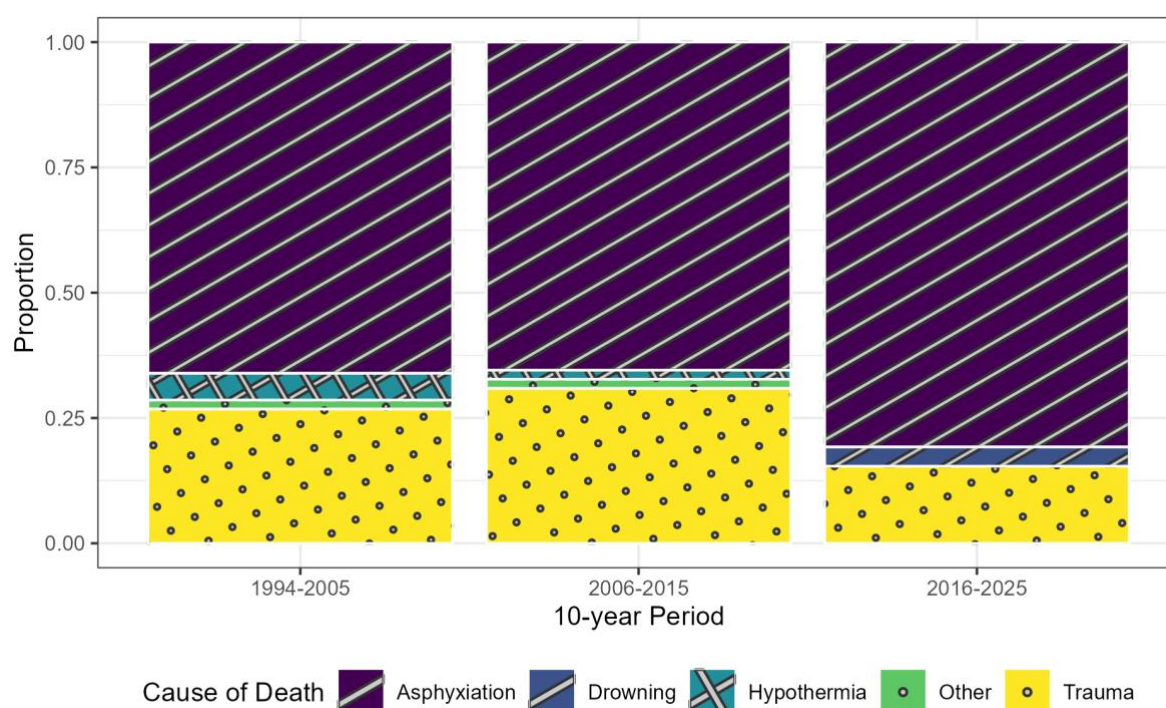


Figure 2. Proportional cause of death, separated by 10-year periods. The proportion of deaths due to asphyxiation increased, with a corresponding decrease in trauma.

3.3 Injury severity score

Autopsy records allowed us to determine ISS scores for 100 of the avalanche victims. We calculated ISS for 72 victims assigned Asphyxiation by coroners and 22 assigned Trauma. ISS differed significantly (Kruskal-Wallis

$H = 51.071$, $df = 4$, $p < 0.001$), with the median ISS almost 10 times larger in trauma victims. Eight of the Asphyxiation victims had an ISS greater than 15, suggesting that traumatic injuries potentially played an important role in their deaths. Conversely, only one victim assigned Trauma had an ISS less than 15, and that victim sustained injuries to their torso and spine.

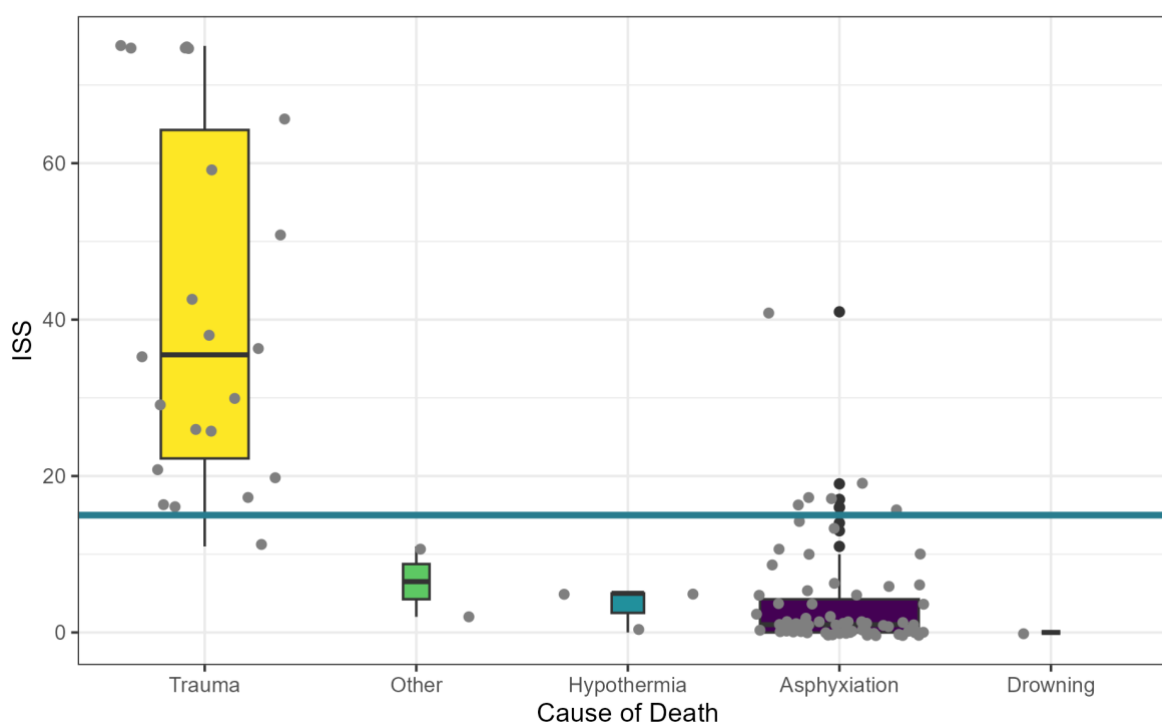


Figure 3. Boxplot of ISS by assigned cause of death. Box width is proportional to the number of victims, and ISS scores are shown as points for individual victims. The horizontal line indicates an ISS score of 15, above which trauma is considered severe.

We grouped traumatic injuries into broad categories based on the region with the most severe injuries. Of the Trauma victims with an ISS score, 23% sustained injuries to the torso or spine, 19% with multisystem trauma, and 9% with head injuries.

3.4 Activity categories

Backcountry Tourers comprised 47% of victims, followed by Snowmobilers (20%) and Sidecountry Riders (15%) (Table 2). Sidecountry riders ascend using ski lifts and descend in the backcountry outside ski area operational boundaries, while backcountry tourers are skiing or snowboarding in the backcountry and primarily ascending under their own power. The absolute number of deaths by activity category did not show significant trends through time or by decade. Proportionally, Backcountry Tourer fatalities have grown significantly over the three 10-year periods (Fisher's exact: $p = 0.047$), increasing 18 percentage points. Snowmobiler, Sidecountry Rider, and Climber fatalities have all declined proportionally.

Table 2. Activity categories of the avalanche victims.

Activity Category	Count	Percent of total
Backcountry Tourer	84	47%
Snowmobiler	35	20%
Sidecountry Rider	26	15%
Climber	14	8%
Snowshoer	4	2%
Inbounds Rider	4	2%
Hiker	4	2%
Ski Patroller/Guide	4	2%
Other	3	2%
Total	178	

3.5 Activity categories and cause of death

The cause of death differed by activity. Climbers had significantly different (Fisher's Exact $p = 0.0271$) causes of death, with more drowning and hypothermia than other groups (Table 3). Climbers comprise just 8% of the total dataset, though. The differences in cause of death become non-significant (Fisher's Exact $p = 0.262$, Chi-squared = 2.7, $p = 0.259$) comparing just the three largest activity categories.

Table 3. Cause of death by activity category

Activity Category	Asphyxiation	Trauma	Hypothermia	Other	Drowning	Unassigned	Total
Backcountry Tourer	56	18		2		8	84
Snowmobiler	29	5				1	35
Sidecountry Rider	15	8	1			2	26
Climber	5	3	3		2	1	14
Snowshoer	2	2					4
Inbounds Rider	1	2				1	4
Hiker	3					1	4
Ski Patroller/Guide	1	2				1	4
Other	3						3
Total	115	40	4	2	2	15	178

3.6 Avalanche characteristics and cause of death

The cause of death differed significantly (Chi-squared = 95.02, $p < 0.001$) based on the avalanche type (Table 4). Wet avalanches (Wet Slab and Wet Loose) had higher than expected rates of trauma but only comprised five victims. Considering just Hard Slab and Soft Slab

avalanches, comprising 95% of the avalanches in the data set, differences were not significant (Chi-squared = 2.33, $p = 0.127$ with continuity correction).

Avalanche Destructive Size did not show significant differences in cause of death. Destructive size only ranged from D1.5 to D3.5 in the dataset, with only seven avalanches D3 or greater.

Table 4. Cause of death by avalanche type

Avalanche Type	Asphyxiation	Trauma	Hypothermia	Other	Drowning	Unassigned	Total
SS	57	25	3			10	95
HS	54	12	1	2	1	3	73
WS	1	2				1	4
WL		1					1
UNK	1						1
U						1	1
R	1						1
L	1						1
I					1		1
Total	115	40	4	2	2	15	178

4. DISCUSSION

In Colorado, asphyxiation remains the primary cause of death in avalanches. This is consistent across similar previously published studies (Romy et al., 2025). Current rescue education in the USA is focused on swift transceiver searches and efficient victim excavation. That emphasis remains important because fast rescues have the potential to intervene before buried victims succumb to asphyxiation. Safety equipment like avalanche airbags has the potential to reduce avalanche burial, which could reduce the potential for asphyxiation.

Trauma accounted for almost a quarter of victims in our study. Proportionally, more victims in Colorado die from trauma than in many other regions (Romy et al 2025). All but one victim with cause of death assigned to Trauma showed substantial injury. That suggests that trauma as a cause of death was rarely mis-assigned by county coroners. Conversely, several victims where coroners assigned asphyxiation as a cause of death also sustained serious traumatic injury. We suggest all avalanche victims undergo an autopsy if possible.

Where we were able to calculate ISS, about 30% of the scores were greater than 15, suggesting

unsurvivable injuries. This suggests rescuers should prepare for seriously injured victims. Importantly, this sample is biased to fatal avalanches. Motivated partly by Sheets et al (2018) and our ongoing research, CAIC has improved the collection of non-fatal avalanche injuries to further our understanding of injury types.

Considering the largest categories, there was no difference in cause of death based on activity groups or avalanche types. That suggests the 3:1 asphyxiation to trauma ratio is stronger than the influence of what people were doing or the type of avalanche they were caught in. People die in avalanches either because they are buried long enough to asphyxiate or sustain serious injury during the avalanche. What they were doing when caught has little bearing on that.

REFERENCES

- Baker, S. P., O'Neil, B., Haddon, W., and Long, W. B.: The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care, *J. Trauma*, 14, 187–196, 1974.
- Colorado Avalanche Information Center (CAIC): Avalanche accident data display & help, <https://avalanche.state.co.us/accidents/help>, last access: 17 August 2026.
- Greene, E., Atkins, D., Birkeland, K., Elder, K., Landry, C., Lazar, B., McCammon, I., Moore, M., Sharaf, D., Sterbenz, C., Tremper, B., and Williams, K.: Snow, Weather and Avalanches: Observation Guidelines for Avalanche Programs in the United States, American Avalanche Association, Pagosa Springs, CO, 2022.
- Romy, C., Eidenbenz, D., Grabherr, S., Zafren, K., Jaques, C., Hall, N., and Pasquier, M.: Causes of death and types of injuries of avalanche fatalities based on forensic data: a scoping review, *Resuscitation Plus*, 26, 101101, <https://doi.org/10.1016/j.resplu.2025.101101>, 2025.
- Sheets, A., Wang, D., Logan, S., and Atkins, D.: Causes of death among avalanche fatalities in Colorado: a 21-year review, *Wilderness Environ. Med.*, 29, 325–329, <https://doi.org/10.1016/j.wem.2018.04.002>, 2018.