SNOW AVALANCHE EXPOSURE AND CONSEQUENCES IN NORWAY

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ABSTRACT: This study provides a national overview of snow avalanche exposure and consequences in Norway across three key sectors: buildings, roads, and backcountry travel. By combining multiple national and regional datasets, we quantify where people, infrastructure, and activities are exposed to avalanche hazard and describe the human and societal consequences associated with avalanche events and disruptions. The exposure of buildings is assessed by combining the national building registry with the most recent avalanche hazard indication maps, which delineate areas potentially affected by snow avalanches with a target return period of 1000 years. This provides a national estimate of the number and spatial distribution of buildings and residents located within avalanche-prone terrain. Avalanche exposure on the public road network is assessed using data from the Norwegian Public Roads Administration, including records of avalanches affecting roads and the frequency and duration of road closures. By combining traffic operation data with traffic volumes, we quantify exposure in terms of the number of vehicles potentially affected by avalanche-related disruptions. Recreational exposure is examined using beacon checker data, submitted GPS tracks, and a wisdom-of-the-crowds approach to estimate current backcountry skiing activity and reconstruct changes in participation between 2005 and 2025. In addition, we examine observed avalanche consequences, including fatalities, injuries, near misses, search and rescue operations and healthcare impacts. Together, these analyses provide a national description of how snow avalanche exposure and consequences are distributed across the Norwegian society and how their relative importance differs between sectors.

KEYWORDS: Avalanche, Exposure, Consequences, Buildings, Roads, Recreation

1. INTRODUCTION

The Norwegian Water Resources and Energy Directorate (NVE) is responsible for reducing societal impacts associated with floods, landslides, avalanches, and urban runoff. To achieve this objective, resources must be allocated across a broad portfolio of risk-reducing measures, including hazard mapping, land-use planning, structural mitigation, monitoring and forecasting, emergency preparedness, and knowledge development. Effective prioritization requires a robust understanding of where people, infrastructure, and activities are exposed to natural hazards and of the consequences these hazards impose on society.

This study focuses on snow avalanches (hereby avalanches) and examines exposure and consequences across three key sectors in Norway: buildings, roads, and recreational travel. Exposure describes the people, infrastructure, and activities located in areas affected by avalanche hazard, whereas consequences describe the resulting impacts when avalanches occur or when measures are taken in response to avalanche hazard. These two perspectives provide complementary information. Exposure indicates the scale and spatial distribution of what is potentially affected, while observed consequences show where avalanches result in fatalities, injuries, disruptions, rescue operations, or other societal impacts. Importantly, high exposure does not necessarily correspond to frequent or severe consequences, and the relationship between the two may differ substantially between sectors.

In this study, we therefore examine avalanche exposure and observed consequences rather than attempting a formal quantitative risk assessment. Where available, information on avalanche probability is incorporated through hazard maps and historical avalanche occurrence, while vulnerability is not explicitly modelled. The analysis is structured around four complementary perspectives: (1) the historical evolution of avalanche accidents in Norway, (2) exposure of buildings, roads, and recreational travel to avalanche hazard, (3) the human and societal consequences of avalanche accidents and disruptions, and (4) a synthesis of how exposure and consequences differ across these sectors in present-day Norway.

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2. A QUALITATIVE DESCRIPTION OF HISTORIC AVALANCHE ACCIDENTS IN NORWAY

The analysis presented here is based on records from the Norwegian National Avalanche Database (NSDB), which contains information on 1437 documented snow avalanche incidents in Norway (NVE, 2026). The database is built on historical documents, local informants, newspaper archives, church records, and official investigations. A particularly important contributor to the historical documentation effort has been Astor Furseth (Furseth, 2006), who over several decades compiled information on thousands of avalanche and landslide accidents across Norway in collaboration with researchers from the Norwegian Geological Survey (NGU) and the Norwegian Water Resources and Energy Directorate (NVE). Since the 1970s, avalanche documentation has become increasingly systematic, with the Norwegian Geotechnical Institute (NGI) responsible for much of the data collection between 1970 and 2008, and NVE maintaining and expanding the database thereafter. Although the completeness varies through time, the NSDB provides a unique long-term perspective on avalanche consequences in Norway.

2.1 *From Settlements to Mountain Travel (1700-1960)*

Historical records indicate that avalanche accidents in Norway were initially dominated by exposure of settlements and farms located beneath steep mountain slopes. Prior to the mid-1800s, many fatal incidents involved entire households being struck in their homes, reflecting a society where the way of life depended on permanent settlement in avalanche-prone terrain. Descriptions from this period often portray avalanches as unavoidable natural disasters and rarely mention road transportation or backcountry travel. During the late nineteenth and early twentieth centuries, expanding road networks, commerce, and winter transportation led to increasing numbers of avalanche accidents involving travelers and workers, moving between communities. At the same time, the first reports of people being caught in backcountry terrain, although these were typically associated with hunting, fishing, seasonal farming, or other necessary activities rather than recreation. By the mid-twentieth century, road-related accidents had become a recognizable component of the avalanche accident record, marking the beginning of a transition from settlement-dominated exposure toward public road transportation and other forms of human activity in avalanche terrain as increasingly important sources of exposure.

2.2 *The Emergence of Recreational Avalanche Accidents (1960-2000)*

From the 1960s onwards, a shift in avalanche exposure became increasingly apparent. Fatalities associated with buildings declined to historically low levels, reflecting improved land-use planning, avalanche mitigation measures, the abandonment or relocation of exposed farms and settlements, and changes in vegetation that reduced avalanche exposure. Climatic changes associated with a rise in treeline elevation and increasing forest density may also have contributed to this development (Eckert et al. 2024). Road-related accidents remained a persistent but relatively stable component of the avalanche accident record, particularly in western and northern Norway where roads pass through extensive avalanche-prone terrain. The most significant change, however, was the rapid growth of accidents associated with backcountry skiing in avalanche terrain. Advances in ski equipment, combined with the emergence of telemark skiing, off-piste skiing, and a broader outdoor recreation culture, enabled increasing numbers of people to access steep winter terrain. Avalanche accidents increasingly involved skiers, and other recreational users, and many incidents were self-triggered rather than the result of unexpected natural events. This period also includes the 1986 Vassdalen avalanche accident (Lied, 1988), in which 16 soldiers lost their lives during a military exercise, highlighting shortcomings in avalanche safety management and leading to substantial changes in avalanche safety practices within the Norwegian Armed Forces.

2.3 *Recreation Dominating Avalanche Accidents (2000-present).*

Since 2000, avalanche fatalities involving buildings have become exceedingly rare, reflecting decades of mitigation efforts and land-use management, and reduced exposure of many settlements. Avalanches on roads continue to pose a hazard, particularly during severe weather events, although their primary consequences are increasingly societal and economic through road closures, transportation disruptions, and isolated communities rather than large numbers of fatalities. Backcountry travel now dominates the avalanche accident statistics. Activities such as ski touring, snowmobiling, mountaineering, and hiking account for the majority of fatalities, with ski touring emerging as the single most common activity. The accident data also indicate a geographic shift in fatal recreational accidents toward northern Norway, consistent with the observed growing popularity of skiing and outdoor recreation in regions such as Troms and Nordland (Toft, 2024). Together, these observations illustrate a fundamental transition in Norwegian avalanche exposure and accident patterns: from a hazard predominantly affecting people in settlements and along infrastructure to one increasingly associated with exposure during backcountry travel.

3. EXPOSURE TO AVALANCHE HAZARD

3.1 Buildings

The most consistent method for quantifying the exposure of buildings to avalanche hazard at the national scale is to combine the national building database with the Norwegian avalanche hazard indication maps (AHIM), which delineate areas potentially affected by avalanches with an approximate 1000-year return period. Using the most recent AHIM (Issler et al. 2023), which accounts for forest density in avalanche runout areas, there are 149,448 buildings in safety class S2 or higher that are located within avalanche-prone terrain. Of these, 55,251 are residential buildings and 44,839 are holiday homes or cabins. Safety class S2 includes buildings where the consequences of an avalanche are considered moderate and where normally no more than 25 people are present. In total, 137,338 people are registered as residing in buildings within the AHIM, corresponding to approximately 2.53% of the Norwegian population. These figures provide a national estimate of potential exposure to mapped avalanche terrain, but do not distinguish between frequently affected locations and areas reached only by very rare events. A separate AHIM dataset developed by the Norwegian Geotechnical Institute (NGI) for the Norwegian Armed Forces with a 100-year return period and could provide an additional basis for differentiating levels of exposure, but was not yet available for inclusion in the present study.

Detailed hazard mapping provides a complementary and more spatially specific description of exposure. Such mapping is available for 52,948 buildings, corresponding to approximately 35% of the S2+ buildings located within the national AHIM. Coverage differs substantially between building types: 29,876 residential buildings, or approximately 54% of AHIM-exposed residential buildings, have been subject to detailed mapping, compared with 5,975 holiday homes or cabins, corresponding to approximately 13% of those identified within the AHIM. Detailed assessments delineate hazard zones corresponding to approximately 100-, 1000-, and 5000-year return periods and therefore provide considerably more information on the level of hazard affecting individual buildings.

However, detailed hazard maps cannot be interpreted directly as a representative national sample of avalanche exposure. Mapping has generally been prioritized towards developed areas where the expected risk is highest, and the mapped hazard zones are typically defined by the governing natural hazard at each location, which may include snow avalanche, rockfall, debris flow, or other processes. For 24,573 of the 52,948 buildings covered by detailed mapping (46%), a governing hazard is defined. Among those, snow avalanche is the governing hazard for 8779 buildings (36%), including 4103 residential buildings and 1376 holiday homes or cabins. Snow avalanches may nevertheless contribute to the hazard at additional buildings where another process have determined the final hazard zone. Consequently, the detailed mapping provides substantially greater information on hazard level at individual sites, but its selective spatial coverage and use of a governing-hazard approach limit its suitability for direct nationwide estimates. The national AHIM therefore provides the most consistent measure of overall potential building exposure, while detailed mapping provides a more refined description of exposure in the subset of areas where such assessments have been undertaken.

3.2 Roads

Exposure of the Norwegian road network to avalanche hazard was characterized at three complementary spatial scales: (1) road segments intersecting the AHIM, (2) road sections officially classified as avalanche-prone by the NPRA (2026), and (3) individual mapped avalanche paths affecting roads by the NPRA (2026). These datasets represent progressively more specific measures of exposure, ranging from modelled exposure across the entire road network to locations where avalanche activity is known to affect roads.

Of the 93,329 km of public road included in the analysis, 10,354 km (11.1%) intersected the AHIM. The proportion varied considerably between road categories: 1225 of 6245 km (19.6%) of European roads, 624 of 3338 km (18.7%) of national roads, 5838 of 44,274 km (13.2%) of county roads, and 2667 of 39,472 km (6.8%) of municipal roads were located within the AHIM. These values should, however, be interpreted primarily as an upper bound of potential terrain exposure rather than as a measure of present-day operational avalanche exposure. The AHIM represents rare events over a return period substantially longer than the age of most Norwegian roads. Much of the present road network was constructed or substantially upgraded after 1950, and road alignments have frequently been designed to avoid known, frequently active avalanche paths. Consequently, the historical observation period for most roads is short relative to the 1000-year hazard represented by the AHIM, limiting its ability to distinguish between roads subject to recurrent avalanche activity and those exposed only under very rare conditions.

A more operational representation is provided by the NPRA database of avalanche-prone road paths for European, national and county roads. The database contains 215 registered sections, corresponding to approximately 1997 km (or 2.2%) of public roads classified as exposed to avalanche hazard. An estimated avalanche recurrence interval was available for 1361 km. Of this length, 705 km (52%) was associated with avalanches occurring at least annually, including 203 km affected several times per year and 1.5 km several times per month. A further 465 km (34%) had estimated recurrence intervals of 2–5 years, while 192 km (14%) were associated with recurrence intervals longer than five years. Recurrence information was unavailable for 636 km. Compared with the AHIM, this dataset therefore represents a substantially narrower but more operationally relevant subset of the road network, identifying locations recognized by road authorities as being exposed and providing an indication of the frequency with which this exposure may be realized.

At the most detailed spatial scale, the NPRA database contains 1427 unique avalanche segments, representing individual avalanche paths or groups of closely related paths affecting roads. A positive nominal annual probability of snow avalanche occurrence was recorded for 1350 points (94.6%), with a median value of 0.10, corresponding approximately to one avalanche every ten years. The estimated frequency varied substantially: 20% of the points had recurrence intervals longer than 20 years, 17% approximately 10–20 years, 22% 5–10 years, and 17% 2–5 years. More frequent exposure was concentrated at a smaller number of locations, with 18% expected to experience avalanches at least once every two years and 11% approximately annually or more frequently.

Together, the three datasets illustrate the importance of scale when describing road exposure to avalanches. The AHIM identifies a broad range of potential exposure, whereas the avalanche-prone road sections and mapped avalanche paths progressively constrain this to locations with recognized or documented avalanche activity. The latter datasets are therefore more representative of current operational exposure, while the AHIM provides complementary information on where rare avalanche events may extend beyond historically observed or presently recognized avalanche paths.

3.3 Travel

Toft et al. (2025) estimated backcountry activity in the Tromsø region by combining GPS tracks with counts from beacon checkpoints. Using the GPS data from Mannberg et al. (2026), 3705 GPS tracks were identified within the Tromsø forecasting region, of which 50.5% passed a beacon checkpoint. Using this relationship, we are able to scale the checkpoint counts resulting in an estimated 51,500 backcountry trips per season for the Tromsø forecasting region.

To estimate exposure at the national level, we assume that the proportion of backcountry skiers who consult the avalanche forecast is comparable across Norwegian forecasting regions. While this represents an important source of uncertainty, it provides a basis for scaling the observed activity in Tromsø to the national population of forecast users. This extrapolation suggests approximately 440,000 backcountry trips per season in Norway. Combining this estimate with the mean annual participation rate of 8.48 trips per person reported by Mannberg et al. (2026) gives an estimated 52,000 active backcountry skiers in Norway.

These estimates provide a first quantitative measure of avalanche exposure for backcountry travel at the national scale and, importantly, a denominator against which avalanche fatalities, injuries, rescue operations, and other consequences can be evaluated. Similar analyses using data from other regions, such as Indre Sogn (Vereide et al. 2026), could provide an independent assessment of the assumptions underlying the national extrapolation and improve the robustness of these estimates in the future.

The GPS data also provides insight into how much avalanche terrain backcountry skiers are exposed to during individual tours. Using the Avalanche Terrain Exposure (ATE) score developed by Mannberg et al. (2026), 17.1% of the 26,703 recorded tours did not enter avalanche terrain at all. Among tours entering avalanche terrain, exposure was strongly skewed towards lower values, with a median ATE score of 25.0, while a comparatively small number of tours accumulated very high exposure. This suggests that although backcountry skiing takes place in mountainous terrain, exposure to avalanche terrain varies considerably between tours, and a substantial proportion of activity occurs with little or no avalanche terrain exposure.

To reconstruct changes in backcountry skiing participation over time, we used a wisdom-of-the-crowds approach. Respondents with long-term knowledge of backcountry activity in their region were asked to estimate the number of active backcountry skiers in 2005, 2015, and 2025. For each year, they provided a best estimate together with lower and upper estimates representing their 20th and 80th percentiles. A total of 37 respondents provided complete best estimates. As absolute participation varied considerably between regions, we assessed temporal change within respondents by normalizing each respondent's estimates to their own 2025 estimate (=100), before calculating the median across respondents. This provides a simplified measure of the typical relative development, acknowledging that growth rates may have differed between regions and that the resulting index is not weighted by regional participation.

The resulting relative activity index was 20 in 2005, 57 in 2015, and 100 in 2025, indicating that respondents, on average, perceived a substantial increase in backcountry participation over the past two decades. If this relative development is cautiously applied to our independent estimate of approximately 440,000 backcountry trips in Norway in 2025, it corresponds to approximately 88,000 trips in 2005 and 250,000 trips in 2015. These values should not be interpreted as direct observations of historical activity, but as a retrospective reconstruction anchored to the independently estimated 2025 activity level. The estimates are subject to considerable uncertainty, particularly because they rely on respondents' retrospective assessments, representation varies between regions, and the elicited 20–80% intervals indicate substantial uncertainty in many individual estimates. Nevertheless, the consistency in the direction of change provides evidence of a marked increase in recreational exposure over the study period.

The reconstructed increase corresponds to an average annual growth rate of approximately 8.4% between 2005 and 2025. Although direct long-term observations of backcountry participation are scarce, this magnitude of growth is consistent with indirect evidence from other countries. Birkeland et al. (2017), using access to avalanche forecasts as an explicitly imperfect proxy for backcountry use, reported 12-, 17-, and 36-fold increases at three US avalanche centers between 1995 and 2017, and conservatively assumed an eight-fold increase in backcountry use over this period. These figures imply growth rates at least comparable to, and generally higher than, the five-fold increase reconstructed for Norway. However, neither approach provides a direct measure of participation: forecast usage may change independently of backcountry activity, while our estimates rely on retrospective assessments by experienced local observers. The similarity in magnitude therefore provides useful context for the Norwegian estimates, rather than independent validation of them.

4. CONSEQUENCES

4.1 Buildings

Historically, snow avalanches affecting buildings have caused numerous fatalities. During the nineteenth century (1800–1899), the available records (NVE, 2026) document 200 avalanche events affecting buildings, resulting in 612 fatalities. Both the number of events and fatalities decreased substantially during the twentieth century (1900–1999), when 81 events and 192 fatalities were recorded. Since 2000, fatal avalanche events affecting buildings have become rare, with only two events and four fatalities recorded. In December 2015, an avalanche from Sukkertoppen in Longyearbyen affected ten residential buildings including 21 people, resulting in two fatalities and six injuries. In March 2023, an avalanche at Reinøya in northern Norway destroyed a farm and killed two residents. These recent events show that, although fatal avalanche impacts on buildings are now uncommon, the consequences can still be severe.

The available data only provides a partial description of avalanche consequences for buildings. NVE does not systematically maintain statistics on avalanches affecting buildings or on evacuations in cases where no fatalities occur. Some events are reported through RegObs or included in the NSDB, but reporting is incomplete and inconsistent, meaning that these sources cannot be used as a complete historical record. Consequently, the present analysis primarily identifies the most severe events involving fatalities.

Future work will aim to develop a more comprehensive understanding of the consequences using complementary historical sources. Insurance records may provide information on buildings damaged or affected by avalanches, while historical evacuation events may be identified through systematic searches of digitized Norwegian newspapers. As Norwegian newspapers have been digitized and are searchable far back in time, they represent a potentially valuable source for reconstructing the frequency and scale of past evacuations. These datasets could not be compiled within the timeframe of the present study and are therefore left for future work.

4.2 Roads

Between the winters of 2013/14 and 2025/26, road-related avalanche accidents accounted for a relatively small share of the recorded human consequences in Norway. Based on the NSDB, 33 incidents involving vehicles were identified, resulting in 41 people being caught by avalanches, 6 injuries, and 1 fatality. In addition, at least 10 individuals were involved in close-call incidents where vehicles were struck by avalanches or narrowly avoided more severe outcomes. Most events were associated with naturally released avalanches impacting roads and vehicles, often during periods of high avalanche danger. Although fatalities were rare, the data demonstrate that avalanches continue to pose a persistent risk to road users, particularly on exposed mountain roads where even medium-sized avalanches can affect vehicles.

Between the 2021/22 and 2025/26 seasons, 1254 avalanche-related road impacts were assessed for European roads, national roads, and county roads across Norway. Of these, 838 closures were caused by avalanches reaching the road, while 416 were preventive closures due to avalanche hazard. Together, these events resulted in 31,660 hours of road closures and affected an estimated 564,000 short vehicles and 88,000 long vehicles. Some uncertainty is associated with these figures, as they are derived from publicly available road messages rather than the NPRA's internal incident reporting system and may therefore not capture all avalanche-related closures consistently.

During the same period, 952 avalanches were recorded on Norwegian public roads. Annual counts varied substantially between seasons, ranging from 109 avalanches in 2021/22 to 304 avalanches in 2023/24, before decreasing to 118 avalanches in 2025/26.

Preventive road closures had a longer mean duration (40.1 h per event) than closures caused by actual avalanches (17.9 h per event). This reflects the prolonged nature of periods with elevated avalanche danger, during which roads may remain closed until conditions improve. In contrast, avalanche-related closures were more numerous and affected a greater number of vehicles, accounting for approximately 319,000 affected short vehicles, compared with approximately 245,000 affected short vehicles during preventive closures. The number of potentially affected vehicles was estimated from the average traffic volume per day reported by the NPRA for each road section and the duration of each closure.

County roads accounted for the majority of closure hours and closure events, reflecting their extensive exposure to avalanche terrain throughout Norway's mountainous regions. However, closures on E-roads and national roads generally affect larger traffic volumes, indicating that disruptions on these routes can influence a greater number of road users despite representing a smaller proportion of all closure events.

Beyond direct impacts on road users, snow avalanches can cause substantial societal disruptions in Norway. Many avalanche-prone roads provide the only year-round connection to remote communities, meaning that prolonged closures may isolate residents from healthcare, job, education, emergency services, and essential supplies. Avalanche activity can also disrupt economic activities, particularly in coastal regions where reliable transportation is critical for the export of seafood products. Delays with fish transport may reduce product quality, increase logistical costs, and affect access to international markets. In addition, road closures can interrupt commuter traffic, tourism, public services, and freight transport, resulting in economic losses that extend well beyond the affected road section.

4.3 Travel

Avalanche fatalities remain the most severe consequence of backcountry travel in avalanche terrain. Between the winters of 2013/14 and 2024/25, 72 people died in snow avalanches in Norway, corresponding to an average of approximately 6 fatalities per winter season. Annual fatalities varied considerably, ranging from 2 to 13 deaths per season.

Using a 5-year moving average, avalanche fatalities in Norway have remained relatively stable over the past decade, fluctuating between approximately 5 and 8 deaths per year. The moving average increased from 5.0 fatalities per year in 2017/18 to a peak of 7.6 in 2022/23, largely reflecting several high-fatality seasons, particularly 2018/19 (13 fatalities) and 2020/21 (9 fatalities). Following this peak, the moving average declined to 5.8 in 2023/24 before increasing slightly to 6.2 in 2024/25. Overall, the data does not indicate a clear long-term increase or decrease in avalanche fatalities, but rather substantial season-to-season variability around a relatively stable average of about 6 fatalities.

Between the winters of 2013/14 and 2024/25, a total of 858 individuals were reported as being caught by snow avalanches in Norway, corresponding to an average of approximately 72 people per winter season. Annual numbers varied considerably, ranging from 11 individuals in 2013/14 to 96 in 2021/22. It is important to note that these figures are a minimum estimate, as avalanche involvements are not systematically reported. While underreporting is likely present throughout the entire study period, it was probably more pronounced during the first few seasons following the establishment of the Norwegian Avalanche Warning Service in January 2013, when reporting routines, data collection systems, and awareness among observers, forecasters and stakeholders were still being developed.

Between the winters of 2013/14 and 2024/25, 515 avalanche-related Search and Rescue (SAR) operations were recorded in Norway, corresponding to an average of approximately 43 operations per year. The annual number of operations varied considerably, ranging from fewer than 20 operations in some years to more than 70 in others. Following a marked increase around 2018, the number of recorded operations has remained relatively stable at approximately 40–60 operations annually.

While avalanche fatalities are the most visible consequence of backcountry travel in avalanche terrain, non-fatal injuries also contribute substantially to the overall societal burden. Data from the Norwegian Trauma Registry (NTR) identified 90 people injured in avalanche accidents during recreational travel between the winters of 2013/14 and 2024/25, corresponding to an average of about 8 avalanche-related trauma patients per year. These are patients whose injuries were serious enough to require treatment within the Norwegian trauma system.

Injury severity varied considerably. The median Injury Severity Score (ISS) was 5 (IQR 2–17), indicating that many patients sustained relatively minor injuries such as isolated fractures, dislocations, or soft-tissue injuries. However, 26 patients (29%) sustained major trauma (ISS ≥15), a threshold commonly used to define severe, potentially life-threatening injuries. The median New Injury Severity Score (NISS) was 9 (IQR 3–21), reflecting that some patients sustained multiple serious injuries. Patients spent a median of 2 days in hospital (IQR 2–5), and 27 patients (30%) required intensive care treatment.

Despite the relatively small number of trauma patients, avalanche accidents frequently required resource-intensive rescue operations. Overall, 56 patients (60%) were transported by helicopter and 20 (22%) by ground ambulance, while the remaining 16 (18%) reached a trauma center by other means. Together, these findings highlight both the severity of many avalanche accidents and the logistical challenges of providing emergency medical care in remote mountain terrain.

At discharge, 38 patients (42%) were classified as having a good recovery (GOS 5), meaning they had returned to normal life with little or no functional impairment. However, 27 patients (30%) had moderate disability (GOS 4), indicating that although they were independent in daily activities, they continued to experience physical, cognitive, or psychological limitations that could affect work or recreational activities. Eleven patients (12%) had severe disabilities (GOS 3) and required assistance with everyday tasks, while 2 patients (2%) remained in a vegetative state (GOS 2), meaning they were alive but had no meaningful awareness of themselves or their surroundings. In addition, 11 patients (12%) died during hospitalization (GOS 1). These outcomes illustrate that many survivors face substantial health consequences even when the avalanche is not fatal, often requiring prolonged rehabilitation and ongoing healthcare support. Trauma registry data therefore complement fatality statistics by providing insight into the broader healthcare burden associated with avalanche accidents and help describe a wider spectrum of avalanche consequences than fatalities alone.

Together, SAR records, trauma registry data, and fatality statistics provide a broader picture of avalanche consequences in Norway. While fatalities remain the most severe outcome, avalanche accidents also generate substantial demands on rescue services, emergency preparedness systems, and healthcare resources.

5. SYNTHESIS OF SNOW AVALANCHE EXPOSURE AND CONSEQUENCES

Taken together, the results show that snow avalanche exposure and observed consequences are not distributed equally across buildings, roads, and backcountry travel in Norway. The potential exposure of buildings within mapped avalanche-prone terrain is huge, but observed consequences have become relatively uncommon. Roads are characterized by recurrent exposure and repeated disruptions, with consequences extending beyond direct avalanche impacts to prolonged closures, affected traffic, and disruption of communities and economic activity. Recreation differs from both sectors, with comparatively mobile and often voluntary exposure, but it is also the most frequent in terms of severe human consequences such as fatalities, injuries and SAR operations.

These differences illustrate that exposure alone is insufficient for prioritizing or assessing the societal consequences of avalanches. Similar levels of mapped or operational exposure may result in very different consequences depending on the type of activity, frequency, and the measures in place to reduce or manage its effects. Conversely, relatively limited exposure may still generate substantial consequences when avalanches affect vulnerable people or critical infrastructure.

A national understanding of avalanches therefore benefits from considering exposure and consequences together, while recognizing that their relationship differs between sectors. The results presented here provide a basis for comparing these differences and for identifying were improved data, mitigation, preparedness, or further analysis may be most valuable.

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AUTHOR CONTRIBUTION

Håvard B. Toft: Conceptualization, Methodology, Formal analysis, Writing - Original Draft. **Pierrick S. Nicolet:** Formal analysis. **Tore Humstad:** Writing - Review & Editing.

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